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# BIOMEDICAL AND BEHAVIORAL RESEARCH SCIENTISTS: THEIR TRAINING AND SUPPLY

## Volume I: Findings

Committee on Biomedical and Behavioral
Research Personnel

Office of Scientific and Engineering Personnel
National Research Council

in collaboration with the
Institute of Medicine

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# BIOMEDICAL AND BEHAVIORAL RESEARCH SCIENTISTS: THEIR TRAINING AND SUPPLY

## Volume I: Findings

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# PREFACE

This is the ninth report examining issues related to the NRSA research training program. The first committee was convened in 1975 as a result of the National Research Service Award (NRSA) Act of 1974, which mandated that postdoctoral training programs funded by the National Institutes of Health (NIH) and the Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA) be restricted to trainees intending to enter a career in research. The NRSA Act was passed at a time when the Office of Management and Budget was challenging the need for postdoctoral research training programs. Although a proposal to phase out funding for all research training programs was unacceptable to the Congress, substantial reforms within the training process were made, including a payback provision for trainees who subsequently selected a career outside of research after the training fellowship.

Another stipulation of the NRSA Act was for the National Academy of Sciences to conduct an ongoing study of training programs and periodically report national needs for biomedical and behavioral research personnel. In the eight previous reports mechanisms were developed to analyze market demand in order to estimate the work force needed to ensure the future viability of biomedical and behavioral research. Consequently, an extensive data base has been developed in addition to analytical models designed for quantitative analyses.

This committee was convened in November 1988 and given only eight months to prepare a report. It has proven to be a most exciting undertaking at a particularly critical time for the biomedical and behavioral sciences in the United States. Significant advances are occurring, and the future is filled with promise for even greater developments in biomedical research leading to an understanding of the fundamental causes of a variety of diseases--from Alzheimer's to cancer--as well as to developing advanced therapies based on this understanding of the etiology and pathophysiologic mechanisms of disease.

There is much work to be done, but will there be sufficient personnel, sufficiently trained, to do it? Factors to be considered in answering the question include:

- the quality of the American school system in educating and encouraging students toward a career in the sciences;
- identifying and correcting the reasons for a continuing dearth of minorities entering careers in research; and
- assessing the relative value and effectiveness of training programs and institutional training grants in producing successful researchers.

The desirability of selecting a career in research also must be examined. Present and future budgetary projections, resulting in decreasing numbers of grants funded by NIH, almost certainly will have a detrimental effect on the attractiveness of an academic research career. It is also necessary to evaluate the effect of the emerging biotechnology industry on the demand for scientists trained by NIH and universities; the impact of industry on standard biomedical and behavioral science research programs; and the role of industry in the training process. Budgetary constraints have also focused interest on health services research because of the size of the health care industry, its proportion of the gross national product, and the intent of government to decrease the amount of money being spent on health care.

Given this environment and the limited time and resources available, this committee sensed that it should do something different from the other committees to date. Specifically, the committee wanted to:

- reexamine and improve the labor market models used to analyze future requirements for research personnel;
- review the literature concerning NRSA program evaluations and evaluation methodology and develop a foundation for future NRSA program evaluations;
- review literature and existing data sets to better define scientific productivity--in academe as well as in industry--as a means to measure NRSA program success;
- call attention to issues related to the program of study for physician/scientists; and
- reflect upon the role of the committee itself and make recommendations for future studies.

Essays addressing these special interests accompany the projections of national needs for biomedical and behavioral research scientists. Thus, Chapter 1 contains a discussion of primary and secondary school education and the points where career decisions are formulated; models are presented to aid in understanding the interventions that must be developed for increased recruitment of minorities into careers in the sciences. Chapters 3 and 5 contain a discussion of the role of the physician/scientist and call attention to the need to carefully examine the program of study of the institutional training grants that serve as the single largest source of research training for the physician. In addition, special papers were commissioned to buttress the committee's deliberations and recommendations. Lloyd H. Smith has provided a concept paper regarding the training and role of the physician/scientist in the modern research arena; Georgine Pion has assessed the evaluation of training programs sponsored by NIH; Elizabeth McGlynn has contributed an overview of health services research; and Helen Gee has addressed the complex task of defining scientific productivity, which is so important for the evaluation process. The committee hopes that it has achieved its goals and that the reader will find this an interesting and provocative report--one that will stimulate new areas of interest for the committee and perhaps new areas of research.

As chairman of the committee, I express my appreciation to the staff members who have worked long and hard within extraordinary time constraints to accomplish our assigned task. I also express my appreciation to the committee members who have given unselfishly of their time by participating in the three meetings in Washington and in the writing, rewriting, and analyzing of this report. The entire committee thanks all those other individuals and organizations who have contributed to our discussions and data base.

Gerald S. Levey, M.D.
Chairman, Committee for Biomedical
and Behavioral Research Personnel

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# CONTENTS

EXECUTIVE SUMMARY 1

The Committee's Investigation 1

Findings 3

Recommendations 6

1. THE ROLE OF NRSA PROGRAMS IN THE EDUCATION PIPELINE 11

Overview 11

The Education/Employment Pipeline 11

The Structure of NRSA Training Programs 17

A Statistical Overview of NRSA Training Programs 19

Grant Applications and Awards by Trainees/Fellows 26

Historical Trends 27

2. THE CURRENT MARKET FOR BIOMEDICAL AND BEHAVIORAL SCIENTISTS 33

Overview 33

The Changing Labor Market for Biomedical and Behavioral Scientists 1973 - 1987 33

Recent Trends in the Labor Market for Biomedical Scientists 35

Recent Trends in the Labor Market for Behavioral Scientists 39

Recent Trends in the Labor Market for Physician/Scientists 42

Composition of the Labor Force 44

3. THE FUTURE LABOR MARKET FOR BIOMEDICAL AND BEHAVIORAL RESEARCH PERSONNEL 51

Overview 51

Prior Committee Projections and Current Methodology 51

The Model 52

The Future Labor Market for Biomedical Scientists 54

The Future Labor Market for Behavioral Scientists 58

The Future Labor Market for Physician/Scientists 63

Prospects for the Longer Term: 1995 to the Year 2000 65

4. TOWARD MEASURING THE EFFECTIVENESS OF NRSA TRAINING PROGRAMS 67

Overview 67

The Aims and Effects of Training and Fellowship Programs 68

The Evaluation of Training and Fellowship Programs 70

A Framework for Program Evaluation 74

A Special Note on the Training of Physician/Scientists 76

5. RECOMMENDATIONS 79

Levels of NRSA Support 79

Data Improvements, Needed Research, Program Evaluation, and Administrative Infrastructure 81

APPENDIX 87

The Emerging Biotechnology Industry 89

Data Needs for Program Evaluation 93

Summary of Employment Trends 99

# EXECUTIVE SUMMARY

## THE COMMITTEE'S INVESTIGATION

This is the ninth report to Congress mandated by the National Research Service Awards (NRSA) Act of 1974, but it is the first report submitted by the Committee on Biomedical and Behavioral Research Personnel. Its predecessor, the Committee on National Needs for Biomedical and Behavioral Research Personnel, produced eight reports and was then disbanded following a 1986 conference that is discussed below. The new committee represented an opportunity for a fresh start, and its members and staff have adopted a sharply different approach to the issue. In particular, this report moves toward a substantially greater emphasis on qualitative issues than heretofore, especially with respect to evaluating the merit of training programs and the productivity of individual careers. This shift in direction reflects the strong recommendation of a panel of experts (see below) but has been constrained by limited time and money: the committee has recommended a program of research, but has been unable to implement it. A mechanism by which NIH can get the work done is also recommended.

The current committee first met in December 1988. The time schedule required that a draft report be completed by July 1989. As a result, the report differs from earlier versions in ways that were undesirable, but unavoidable. One major departure from previous committee efforts is the abandonment of a formal projection model for physician/scientists. The committee felt that the existing data are inadequate to properly define and track physician/scientists; without a historical data series it was impossible to build a credible model. The committee has also had to forego any serious consideration of dental, nursing, and health services research in the report, although it did commission the paper on health services research that is contained in Volume III of this report. (Volume II contains an updated and enlarged version of the set of tables that appeared as an appendix of the 1985 report.) If the organization and timetable that are recommended for the 1993 report are adopted, these topics can be reintroduced in it.

In the time that it had, the committee elected to examine the educational process that leads to doctoral degrees in biomedical and behavioral science (and to postdoctoral study in some cases) and the role of NRSA training programs in it. Conclusions from this examination are provided, beginning on page 3. The congressionally mandated analysis and a new and broader projection of the labor market for biomedical and behavioral scientists are described in Chapters 2 and 3. The committee gave greater emphasis to the identification of a research agenda for filling gaps in knowledge needed for sound policy decisions in this area. The committee was able only to sketch such an agenda, presented in Chapters 4 and 5, which if implemented promptly should contribute to a particularly strong 1993 report.

The committee's examination of needed research owes much to an intensive discussion of the subject that occurred during the Airlie House Conference on Research Training (Warrenton, Virginia, November 24-25, 1986), sponsored by the Institute of Medicine. The fruit of that conference was proposals for three major initiatives:

1. undertake in-depth evaluations of NIH-supported training programs;

2. develop improved measures of scientific productivity; and

3. improve the assessment of national needs for biomedical and behavioral scientists.

The first two Airlie House initiatives, training program evaluation and productivity analysis, represent an important concentration of the committee. Papers commissioned on each topic are contained in Volume III. These papers form the basis of Chapter 4, which is concerned entirely with these topics and represents an important innovation of the current report.

The topics of program evaluation and productivity analysis are linked naturally by the assumption that effective research training programs should have measurable outcomes--namely, enriching research careers and increasing the volume and quality of their output. Research with which to test this assumption in depth is recommended in Chapter 5. The committee also makes the assumption that increased financial support of graduate education, such as that for NRSA programs, yields both an increased number of graduate students and an accelerated path to the doctorate.[1]

The program evaluations recommended by the committee are intended to get at issues beyond those of effective educational enhancement. They are intended also to investigate potential negative impacts, such as the possibility that the programs reduce the quality of students available for research assistantships or that the grants may not be used to increase the number of qualified graduate students but, rather, to substitute for other money that is then used for other purposes.

The third Airlie House proposal was to extend coverage of future reports beyond the academic sector--the primary concern of earlier reports--particularly to include industry and its burgeoning biotechnology subsector. This is done in Chapters 3 and 4. The committee also examines the rapid changes in sex and race/ethnic composition of the biomedical and behavioral work force; these changes may have major implications for training programs, labor supply, and the research process itself.

The committee's counts and projections of biomedical and behavioral scientists are more comprehensive than in the past and represent an improvement over earlier projections. However, the current model is still forced to make simplifying assumptions that may be unrealistic but that are necessitated by inadequate information. For example, the current model continues the assumption that the labor market for scientists is strictly national, with no local or regional barriers. It is also assumed that any two individuals with degrees in a given field can occupy any job in that field equally well. Mobility among fields of science and into and out of science are taken into account in the models, but are assumed to occur independently of economic or other field characteristics that change over time. The committee did not devote extensive resources to an analysis of postdoctorates because this issue has been thoroughly examined in the past and because there has been very little change in the size of the postdoctoral pool in recent years. Although the current model represents a distinct improvement, its assumptions merit a closer and more critical empirical examination than was possible in the period of this study.

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[1] Empirical evidence suggests that first-year graduate enrollments are positively associated with total student support and starting wages and negatively associated with total elapsed time to degree. See Joe G. Baker, "The Ph.D. Supply Crisis: A Look at the Biomedical Sciences," paper given at the Western Economics Association Meeting, Lake Tahoe, Nevada, June 1989. The influence of student aid on time to degree is examined in Howard Tuckman, et al., *On Time to the Doctorate*, forthcoming from the National Research Council.

Nevertheless, these labor market descriptions and projections have convinced the committee that there is need for changes in the level of support in biomedical graduate education. The projections played a weaker role than previously in determining the level of support that the committee finally recommended. In prior reports, recommended levels of support were fairly direct outputs of the models used, but in this report the recommendations are products of the collective judgment of the committee, taking the projections into account. For future committees, the recommended program evaluations and related research should prove to be powerful supplements to the output of projection models.

None of this should be taken to suggest that the previous committee ignored any of the topics that we consider here. For example, the 1981 report contained a chapter on the race/ethnic composition of the biomedical and behavioral work force, but sex was not included. Both the 1983 and 1985 reports described ground-breaking surveys of scientific employment in biotechnology firms. Instead, we believe that we have an evolving perspective with a substantially greater emphasis on vital issues that determine the quality of the biomedical and behavioral scientific work force.

## FINDINGS

Under the terms of the NRSA Act and its directive to NIH, the committee was asked to address several implicit or explicit research questions. The following summary of this report is couched in the form of responses to seven questions.

1. **What are the kinds, extent, and length of existing research training mechanisms in biomedical and behavioral science?**

   There exists no complete inventory of the nation's training mechanisms for biomedical and behavioral science. However, it is clear that they operate within graduate and medical schools and consist mainly of traditional Ph.D. and M.D. programs, with many special programs funded by external sources.

   The major individual training mechanism is NIH, which awarded $238.8 million in NRSA training funds in 1987. In addition to NIH, the Alcohol, Drug Abuse and Mental Health Administration (ADAMHA) awarded $23.5 million, and the Health Research Services Administration (HRSA) awarded $1.2 million in NRSA training funds in 1987. These funds support a large array of training mechanisms, including limited baccalaureate training, predoctoral and postdoctoral institutional grants and fellowships, and career development programs for senior scientists. A historical summary of NRSA support appears in Table 1, page 7.

2. **How do existing training mechanisms compare in efficiency?**

   Previous studies of NRSA research training found that program participants performed better than nonparticipants in their subsequent research careers. The design of these studies makes it impossible to determine whether the differences are effects of the training programs or of the selection process. Data and methodological improvements are needed for a true evaluation of the efficiency of NRSA training programs. Even in the absence of systematic data, however, the committee acknowledges inefficiencies in some training programs. In particular, committee members affiliated with medical schools believe that the program of study in M.D. research training programs is deficient in basic scientific content.

3. **What is the current state of the labor market for biomedical and behavioral scientists?**

**Biomedical scientists**: Demand (job openings) has been growing relative to supply (new Ph.D.s) since the early 1980s. Industrial employment growth is over twice the rate of academic employment growth. The proportion of employed biomedical scientists whose work involves primarily research and development (R&D) has increased.

**Clinical psychologists**: Total employment of clinical psychologists has been growing rapidly in the 1980s. The supply of new Ph.D clinical psychologists has not kept pace with this demand. However, only a very small (and declining) proportion of employment is R&D-related; because of this, the committee gives very little consideration to this field.

**Nonclinical psychologists**: The labor market for nonclinical psychologists in the 1980s has been in approximate balance. Employment of nonclinical psychologists is dominated by the academic sector, which has had sluggish demand as a result of falling enrollments. A substantial number of nonclinical psychology Ph.D.s have switched fields to work as clinical psychologists, although this number should decline as state certification requirements increase. The portion of nonclinical psychologists who are involved in R&D work has been fairly stable at about 30 percent of total employment.

**Other behavioral scientists**: The labor market for other behavioral scientists (anthropologists, sociologists, audiologists, and speech pathologists) has been fairly stable in the 1980s; declines in annual job openings have been matched by declines in Ph.D. production. Over 80 percent of these scientists ~~are employed~~ at colleges and universities, where employment growth has averaged 4.2 percent annually. The portion of other behavioral scientists involved in R&D has remained constant at approximately 19 percent.

**Clinical investigators**: The number of NIH traineeships/fellowships for post-professional research training of M.D.s has not increased as fast as health-related R&D expenditures. The percentage of M.D.s who are principal investigators (PIs) on NIH research grants has fallen, although the number of M.D. PIs has remained constant for the last decade at between 1,700 and 2,000.

4. **What is the expected future labor market for biomedical and behavioral scientists?**

**Biomedical scientists**: Most new positions in biomedical science are expected to be in industry. Unless demand growth falls considerably from historical levels and/or enrollments and degree production increase dramatically, there is projected to be an undersupply of biomedical Ph.D.s into the next century. The undersupply is expected to be even greater in the R&D segment.

**Clinical psychologists**: An undersupply of new Ph.D.s in clinical psychology is expected unless growth moderates considerably or degrees and enrollments increase. However, most of this projected growth will be for counseling; future demand for R&D clinical psychologists will be extremely small.

**Nonclinical psychologists**: The projected labor market for nonclinical psychologists is characterized by approximate balance between supply and demand. However, the strong market for clinical psychologists could draw off labor supply from the nonclinical sector.

**Other behavioral scientists**: The labor market for other behavioral scientists is projected to be characterized by supply and demand balance through the year 2000. In the R&D sector, demand growth is projected to exceed supply growth by a modest margin.

**Clinical investigators**: For all physicians, growth in supply is expected to exceed that of demand by a large margin through the year 2000. For physician/scientists, however, demand may continue to increase as national health R&D expenditures increase.

5. **What is the current state and expected future state of the labor market in the biotechnology industry?**

   Based on the results of our survey of biotechnology firms (see Appendix A), more firms are having problems hiring scientists this year than last year. Over one-third reported having labor shortages (vacancies for over 90 days) in the last year. Over 80 percent of biotechnology firms plan to maintain or increase current levels of hiring, particularly those with postdoctoral training.

6. **What are the numbers and conditions of women and minorities seeking careers in biomedical and behavioral sciences?**

   Females have made tremendous strides in the biomedical and behavioral work force in terms of levels of predoctoral support, Ph.D. degrees received, and postdoctoral appointments. However, the labor force particpation of females in full-time science continues to lag behind males.

   The number of minority scientists, on the other hand, has experienced very little change in status in recent years and continues to lag behind by almost every measurement of participation in science. Given the strong commitment of NIH and ADAMHA to increase the numbers of minority scientists, of particular concern was the finding that minorities are underrepresented in predoctoral support by NIH. Reasons for this underrepresentation are unclear.

7. **What data resources need to be maintained or established to carry out the necessary analyses for this study?**

   Several data sets have been essential to the conduct of this study, including the following: Survey of Earned Doctorates (SED); Survey of Doctorate Recipients (SDR); Information for Management, Planning, Analysis and Coordination (IMPAC); the Trainee Fellow File (TFF); and Consolidated Grant Application File (CGAF).[2] As vital as they are to the work of this committee, however, they are flawed in a number of ways. More important than the flaws is their incompleteness. Only the SDR provides career outcome measures, for example, and the sample size of the SDR is too small to permit accurate inferences about outcomes of particular sets of trainees. The committee has proposed a continuing program evaluation data matrix that would provide more adequate information.

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[2] The SED is a continuing survey of doctoral candidates administered by the graduate schools at the time of completion of all requirements for the doctoral degree. The SDR is a biennial sample survey of doctoral scientists that focuses on many aspects of the career. The IMPAC and CGA files are maintained by NIH, the former concerned with research grant and training programs and that NIH/ADAMHA administers and the latter with research grant applicants.

## RECOMMENDATIONS

### NRSA Support Levels

The committee's recommendations for levels of NRSA training support are summarized in Table 1.

- *Biomedical sciences*: The committee projects that growth in demand will exceed that in supply through the year 2000. The committee recommends that the level of predoctoral support be 5,200 full-time equivalent positions (FTEPs), up from the current level of 3,681. To shorten the time to degree and to reduce graduate student attrition, the committee suggests that NIH examine the potential effectiveness of a support program tailored specifically for student support during the thesis-writing stage. The committee also recommends that postdoctoral support be increased gradually as degree production increases.

- *Behavioral sciences*: The committee projects that the labor market for behavioral scientists will be fairly stable. The committee recommends that the level of behavioral science predoctoral and postdoctoral support be kept at their current levels of approximately 500 and 420 FTEPs, respectively. Given the low level of research involvement by clinical psychologists, the committee recommends moving support away from clinical psychology and towards nonclinical psychology and other behavioral sciences.

- *Clinical sciences*: The committee expects that the demand for physician/scientists will increase in the future as health-related R&D increases, but in the absence of compelling data, this is speculative. Given the lack of data about supply/demand and questions about the effectiveness of physician research training, the committee recommends that the number of trainee and fellow positions for M.D. investigator training remain essentially the same until current training programs are evaluated.

- *Health services research*: This interdisciplinary activity requires individuals trained in a variety of fields, including not only medicine but also economics, public health, sociology, statistics, psychology, and other natural and social sciences. Given the potential for increased demand for scholars in health services research, the committee recommends that research training for biomedical, behavioral, and M.D. scientists in this field be increased. The current funding mechanism for NRSA health services research training allocates one-half of 1 percent of NIH's NRSA budget to HRSA for research training.

In order to support the recommended increases in NRSA research training, the 1987 NIH/ADAMHA/HRSA training budget of over $262.2 million would have to be increased to approximately $282 million in 1990 and grow at approximately $10 million per year to a 1993 total of $312 million.[3] This represents a real growth rate of approximately 3.5 percent per year.

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[3] These budget estimates are based on an average cost per trainee of $24,851 and fellow of $25,920. These averages were computed using budget data from the *NIH Data Book 1988*, Table 16, and the "ADAMHA NRSA Training Tables 1987," Table 1. Trainee/fellow data are from Table I.1.

Table 1. Committee Recommendations for NRSA Full-Time Equivalent Training Positions, 1989-1995, and Actual Full-Time Equivalent Training Positions, 1985-1987

| | Actual | | | Recommended | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1985 | 1986 | 1987 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
| Biomedical | 7741 | 7807 | 7387 | 7800 | 8200 | 8600 | 9000 | 9400 | 9400 | 9400 |
| Predoctoral | 4008 | 3856 | 3681 | 4000 | 4300 | 4600 | 4900 | 5200 | 5200 | 5200 |
| Fellow | 92 | 93 | 86 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Trainee | 3916 | 3762 | 3594 | 3900 | 4200 | 4500 | 4800 | 5100 | 5100 | 5100 |
| Postdoctoral | 3733 | 3952 | 3707 | 3800 | 3900 | 4000 | 4100 | 4200 | 4200 | 4200 |
| Fellow | 1628 | 1817 | 1580 | 1600 | 1650 | 1700 | 1750 | 1800 | 1800 | 1800 |
| Trainee | 2106 | 2135 | 2127 | 2200 | 2250 | 2300 | 2350 | 2400 | 2400 | 2400 |
| Behavioral | 971 | 962 | 924 | 920 | 920 | 920 | 920 | 920 | 920 | 920 |
| Predoctoral | 530 | 515 | 504 | 500 | 500 | 500 | 500 | 500 | 500 | 500 |
| Fellow | 40 | 33 | 37 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| Trainee | 490 | 482 | 467 | 460 | 460 | 460 | 460 | 460 | 460 | 460 |
| Postdoctoral | 441 | 447 | 420 | 420 | 420 | 420 | 420 | 420 | 420 | 420 |
| Fellow | 91 | 91 | 95 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Trainee | 350 | 356 | 324 | 320 | 320 | 320 | 320 | 320 | 320 | 320 |
| Clinical | 2195 | 2229 | 2157 | 2150 | 2150 | 2150 | 2150 | 2150 | 2150 | 2150 |
| Predoctoral | 632 | 687 | 654 | 650 | 650 | 650 | 650 | 650 | 650 | 650 |
| Fellow | 2 | 6 | 17 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Trainee | 630 | 681 | 637 | 640 | 640 | 640 | 640 | 640 | 640 | 640 |
| MSTP | 629 | 661 | 636 | 640 | 640 | 640 | 640 | 640 | 640 | 640 |
| Other | 1 | 20 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Postdoctoral | 1563 | 1542 | 1503 | 1500 | 1500 | 1500 | 1500 | 1500 | 1500 | 1500 |
| Fellow | 181 | 139 | 113 | 110 | 110 | 110 | 110 | 110 | 110 | 110 |
| Trainee | 1382 | 1403 | 1390 | 1390 | 1390 | 1390 | 1390 | 1390 | 1390 | 1390 |
| Total | 10907 | 10998 | 10468 | 10870 | 11270 | 11670 | 12070 | 12470 | 12470 | 12470 |
| Predoctoral | 5171 | 5058 | 4839 | 5150 | 5450 | 5750 | 6050 | 6350 | 6350 | 6350 |
| Fellow | 135 | 132 | 141 | 150 | 150 | 150 | 150 | 150 | 150 | 150 |
| Trainee | 5036 | 4925 | 4698 | 5000 | 5300 | 5600 | 5900 | 6200 | 6200 | 6200 |
| Postdoctoral | 5737 | 5941 | 5629 | 5720 | 5820 | 5920 | 6020 | 6120 | 6120 | 6120 |
| Fellow | 1899 | 2047 | 1788 | 1810 | 1860 | 1910 | 1960 | 2010 | 2010 | 2010 |
| Trainee | 3838 | 3894 | 3841 | 3910 | 3960 | 4010 | 4060 | 4110 | 4110 | 4110 |
| HRSA (not include in above figures) | NA | NA | NA | 77 | 79 | 81 | 83 | 85 | 85 | 85 |

NOTE: Totals may not add due to rounding. All figures are in full-time equvilalent trainee/fellow years. Actual appointments in 1987 were 12,041 (10,815 NIH and 1,226 ADAMHA). Appointments exceed FTE trainee/fellow years (10,468 in 1987) because of partial-year appointments. Does not include short-term training positions.

SOURCE: Historical data are from Table 1-5.

**Needed Research**

- *Program of study for physician/scientist training*: This committee recommends that a conference, committee, or study be implemented to examine the program of study for physician/scientist training supported by postdoctoral institutional training grants. This investigation should focus on the potential merits of including more exposure to basic science and scientists in these training programs.

- *Studies of recruitment and retention*: We need far more comprehensive knowledge than we have concerning factors that facilitate recruitment and retention of able students at all stages of education leading to careers in science. These studies should emphasize the recruitment and retention of women and minorities.

- *Survey studies of former trainees with control groups*: This should be a first step in evaluating the relative efficiency of NIH training mechanisms. Study populations should consist of cohorts of entrants to graduate school rather than Ph.D. recipients. The committee recommends that the first two programs to be evaluated in this fashion be the Minority Access to Research Careers (MARC) and the Medical Scientist Training Program (MSTP).

- *Studies of women and minorities*: The academic pipeline for women is coming more and more to resemble that for men in biomedical and behavioral sciences. Evidently, NIH and other training programs are working effectively, at least in terms of their recruitment and retention through the doctorate. However, once into the career, the professional behavior of women and men continues to differ in important regards, such as numbers of papers published and citations received. The committee suspects, but lacks data with which to show, that some of these differences result from different experiences in graduate school. The committee lacks the evidence on which to base concrete recommendations in this regard, but does suggest a program of research that is intended to provide specific guidelines.

  In the case of targeted minorities, recruitment and retention into careers in biomedical and behavioral science remain worse than for whites. Little is known about the careers of minority scientists; we can only assume them to resemble those of women more than those of white males. Again, the committee lacks data with which to make concrete recommendations for intervention and can only recommend research designed to provide them. NIH has several important recruitment programs, such as Minority Access to Research Careers, but measurable changes in numbers of targeted minorities are not yet being seen. Although there are several potential causes of this lack of minority progress in biomedical and behavioral science, this could suggest that these programs are ineffective. The program evaluations proposed by the committee will make this determination possible.

- *Improvements in data and information*: The committee also recommends a number of specific improvements in the data sets needed to support more rigorous future analyses.

**Other Recommendations**

- *Interdisciplinary programs*: To meet changing national priorities, the committee urges NIH to continue to evolve its pre- and postdoctoral programs, and we support the need for some of these programs to be interdisciplinary in nature (e.g., health services research).

- *Needed organization with which to implement these recommendations*: Given the research and evaluation agenda detailed in this report, the committee recommends that a new committee be activated no later than January 1992 in order to allow two years for the preparation of the 1993 report.

# CHAPTER 1

# THE ROLE OF NRSA PROGRAMS IN THE EDUCATION PIPELINE

## OVERVIEW

The "pipeline" to a career in the biomedical and behavioral sciences starts early, and each stage is dependent on the stage before it. Unfortunately, it is far easier to leave the pipeline than to get into it at a later stage. As a result, there are fewer and fewer young people at each successive stage. The pipeline leaks.

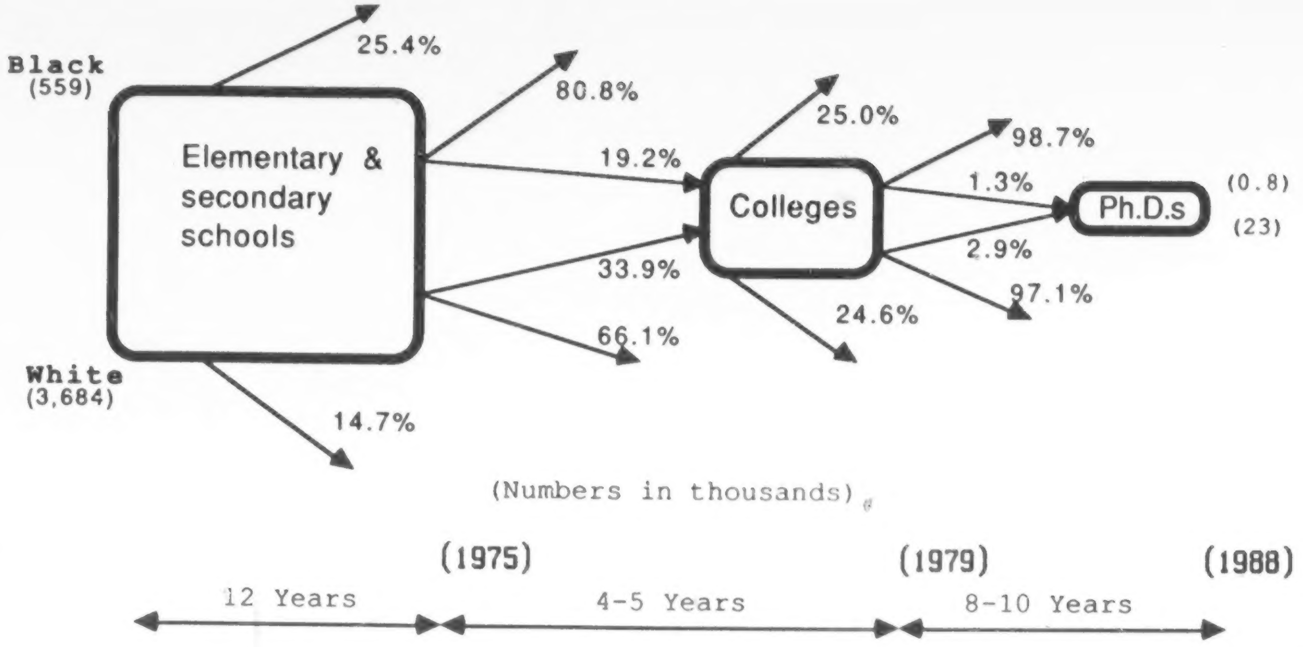
The National Research Service Act (NRSA) supports a number of programs that are designed to maintain an adequate supply of biomedical and behavioral personnel, with the quality and skills needed to support increasingly sophisticated biomedical research. The effectiveness of the NRSA programs, which are primarily aimed at postbaccalaureate training, is constrained by the level and quality of students at that stage in the pipeline. The most important of these programs are *training grants*, given to institutions, and *fellowships*, awarded to individuals. A smaller number of non-NRSA career award grants provide clinical research support and experience for young physician/scientists and others.

The total number of NRSA training positions supported by NIH and ADAMHA has remained steady, at between 10,000 and 11,000 per year, since 1978. Trends within that total, however, show that support has been shifting from predoctoral to postdoctoral training. Biomedical sciences dominate these programs, with 70 percent of all positions in 1987, equally distributed between pre- and postdoctoral. In the behavioral sciences, support for predoctoral positions has declined since 1982 but still outweighs that for postdoctoral positions. Clinical sciences received only 20 percent of NRSA support in 1987, with most of it going to postdoctoral positions.

## THE EDUCATION/EMPLOYMENT PIPELINE

The charge of this committee requires it to examine the United States' work force of biomedical and behavioral scientists not merely as sets of numbers, but also as human beings, some of whom have extremely productive careers, others who have less so, and still others who drop out altogether. To gain some understanding of this variability--and to determine whether the many millions of dollars that NIH/ADAMHA annually invests in the training of scientists makes any difference--it is necessary to think longitudinally about scientists' training and careers.

All education systems can be considered in terms of a conceptual pipeline that students enter after meeting certain requirements and through which they pass from one stage to the next based on individual preferences, abilities, and responses to institutional circumstances and public policies. The pipeline leading to Ph.D. and M.D. degrees and entry into the scientific work force can be thought of as a series of interconnected pools. Figure 1-1 shows the rates of recruitment, retention, and graduation for white and black students as they progress from elementary and high school, to undergraduate college, graduate and professional schools (medical, dental, etc.), and finally to the receipt of doctorates. This figure demonstrates the length of the process that produces a qualified


Black
(559)
White
(3,684)
Elementary & secondary schools
25.4%
14.7%
80.8%
19.2%
33.9%
66.1%
Colleges
25.0%
24.6%
98.7%
1.3%
2.9%
97.1%
Ph.D.s
(0.8)
(23)
(Numbers in thousands)
(1975)
(1979)
(1988)
12 Years
4-5 Years
8-10 Years

SOURCE: Appendix Table A-5.

**Figure 1-1.** The academic pipeline for persons ever attending U.S. elementary and secondary schools, by race, 1975 to 1988.

scientific work force--at least 23 years, including elementary and secondary schools.[1] It follows from the extreme length of this process that:

1. the market-ready scientists of the year 2000 are now college sophomores; and

2. early intervention is required to change significantly the flow of individuals to specific science programs.[2]

Three basic forces determine the movement of students into and through the pipeline into science:

- *Readiness*: At every level of the pipeline, readiness to move ahead is determined by the individual's capacity to construct, transmit, and receive ideas that are formulated mathematically. Mastery of an appropriate level of mathematics is necessary, but clearly not sufficient, to entering and remaining in the pipeline.[3] Increasingly, a detailed knowledge of the substance and methods of science is also a necessary characteristic of readiness. In addition, readiness of an individual is influenced by a large set of factors, chief among them probably being one's innate ability and family values regarding education and knowledge.

- *Recruitment*: Given that one is ready to enter the pipeline to science, whether one actually does so is the result of a complex set of circumstances. While family values concerning the worth of science are critical in reaching the decision to pursue a scientific career, the quality of precollege science and mathematics instruction is equally important to the recruitment of capable students into the science pipeline. Some studies have indicated that the decision to enter the science pipeline is made in high school or even earlier, but that "by college graduation only 35 percent of the high school seniors who planned mathematics, science, or engineering (MSE) majors have stayed with their plans."[4] These losses may be important, but it may also be unreasonable to expect binding career commitments by the final year of high school.

- *Retention*: It is probably fruitless to examine retention in the science pipeline earlier than the junior year of college, when majors usually are declared. By that time, in addition to family, peer, faculty, and other significant influences, another factor taking on great significance is the availability of financial support. Money serves both as a barrier to acquiring the advanced training needed for a scientific career and as a force motivating one to drop out of the pipeline in favor of more lucrative alternatives. As Figure 1-2 makes clear, retention rates are so poor in biomedical and behavioral graduate programs that there is a potential for significant improvements, with consequent increases in the numbers of new doctoral scientists each year.

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[1] Indeed, in the cases of those whose education includes obtaining M.D. and Ph.D. degrees and a substantial period of postdoctoral study, the time from entry into the school system to entry into the work force can be as long as 30 years. It should be noted, however, that during the last 10-12 years, such students are contributors to the nation's research productivity.

[2] For instance, only those college students who have obtained mathematics and quantitative science credits in high school can opt for scientific careers.

[3] See P. R. Rever, *Scientific and Technical Careers: Factors Influencing Developing During the Educational Years*, Iowa City: The American College Testing Program, 1973.

[4] Government-University-Industry Research Roundtable, *Nurturing Science and Engineering Talent: A Discussion Paper*, Washington, D.C.: National Academy Press, 1987, p. 29.

It is clear that many factors influence the size of the cohorts in each pool of the education/employment pipeline. Decisions made by individuals are combinations of personal, financial, and contextual elements--influenced by the behavior of individuals, the advice and guidance of counselors and mentors, and individual perceptions of the status of a scientific career and national priorities. Assessments of how to influence the flow of individuals through this system must take into account such factors.

A high school graduate may choose to enter the work force immediately, enroll in a junior college before entering a four-year university, or matriculate at a university directly from high school. But the availability of these options is altogether contingent on the level of readiness. Only with adequate mathematics and science preparation in high school does the student have the option to enter college science programs that can lead to subsequent graduate or professional school work. Inadequate science and mathematics performance in middle school frequently reduces the options and shunts the high school student to a noncollege program or to a delay of college entry for remedial work. This path is particularly common for minority students, who frequently lack crucial information and institutional attention early in their careers.

### The Pipeline into the Basic Biomedical Sciences

Entry into college is the point at which the data permit us to focus on the fields of concern here. Figure 1-2 shows the current pipeline from the point of college matriculation. This figure again emphasizes the fact that the pipeline is extremely "leaky." The number of B.A./B.S. degrees in biomedical science is much less than the number of freshmen who four years earlier expressed the intention of earning such a degree. Far more of the leakage is into other fields, especially those that are business-related, than out of college. The number of baccalaureate degrees with majors in the biological sciences rose steadily to a peak of 52,000 in 1976 but then declined until 1984, when a new upward trend began. Currently, about 37,000 bachelor's degrees in the biological sciences are awarded annually by U.S. institutions (see Volume II of this report, Table 2).

At the next stage of the pipeline, entry into graduate or professional school, individual preferences and responses to environmental factors greatly influence the decision to pursue and complete a graduate or professional program and to enter a career in science. Students completing graduate programs, as well as a small proportion of those completing the M.D. or another professional biomedical program, can move directly into the work force,[5] choosing careers in academe, industry, or government.[6] Others opt forpostdoctoral training, a percentage that approximately doubled between 1972 and 1982

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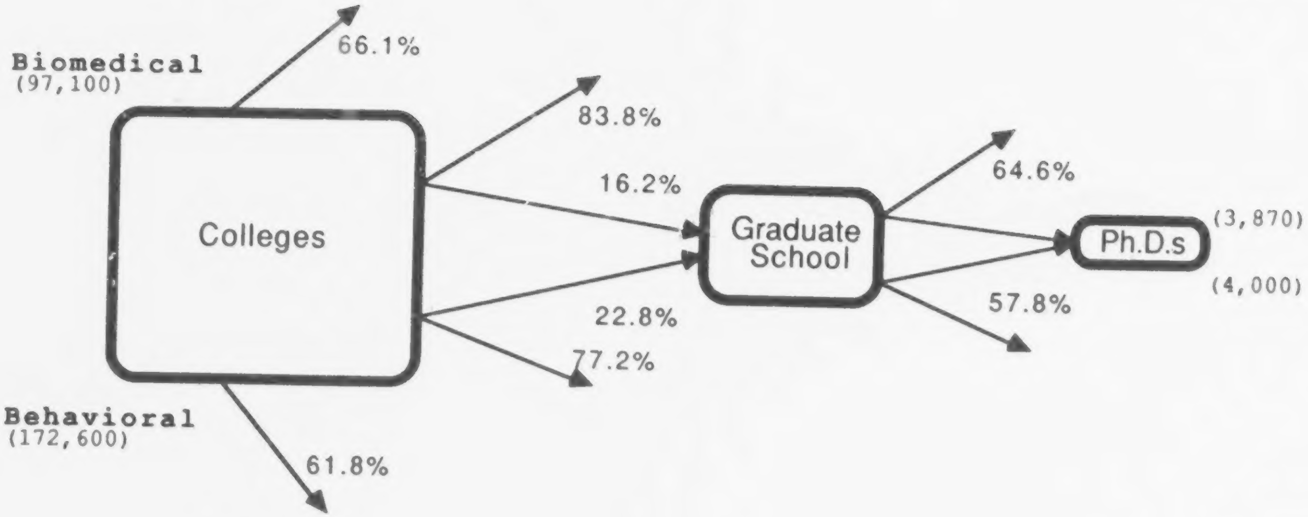
[5] Those pursuing a career in basic research would probably undertake postdoctoral training first. A relatively small proportion of those completing graduate programs move to professional training.

[6] The length of time spent in research careers is highly variable, but attrition rates from the work force have been relatively low--amounting to 2-3 percent per year in biomedical science and not quite 5 percent in behavioral fields. Because the average age of the work force has increased steadily, however, attrition rates are projected to increase within the next decade.


Biomedical
(97,100)
66.1%
Colleges
83.8%
16.2%
22.8%
77.2%
Behavioral
(172,600)
61.8%
Graduate School
64.6%
57.8%
Ph.D.s
(3,870)
(4,000)

SOURCE: Appendix Table A-6.

**Figure 1-2.** The academic pipeline for biomedical and behavioral sciences, selected years.

but has since remained level. About 8,200 individuals currently are engaged in postdoctoral training in the biomedical sciences.

The professional and graduate biomedical degree programs have significantly different attrition rates: whereas attrition from professional programs seems relatively minor,[7] that from graduate programs appears to be as high as 58 percent.[8] High attrition rates may be influenced by the length of postdoctoral training and/or the availability of federal funds in the biomedical sciences. The data may also be unintentionally misleading --some proportion of the first-year graduate students may successfully attain the terminal master's degree that they had intended and thus blur the comparison between first-year graduate students and doctorate recipients eight years later. Even if this proportion were large, however, the amount of leakage during graduate school would remain high enough to merit careful analysis.

The steadily increasing size of the pool of postdoctoral biomedical scientists has raised concern for many years.[9] However, funds to support postdoctoral training come largely from federal grants, contracts, and fellowships. The size of the pool therefore reflects directly the national priority for biomedical research: the postdoctoral pool, as well as the graduate pool, is a major contributor to the research programs of granting agencies. The ways in which federal support is provided, the criteria used to evaluate programs, and the success of individual participants are discussed in Chapter 4.

Finally, annual attrition from the biomedical science work force (due to death and retirement) has been approximately 1,200 recently and is expected to increase to nearly 1,700 within the next decade. Recognizing this, as well as the fact that only approximately 1.1 percent of individuals with doctorates in the biomedical sciences are unemployed, the committee stresses that the present production rates are inadequate to meet current national needs.

**The Pipeline into Behavioral Sciences**

Figure 1-2 also illustrates pool sizes and leakages from the pipeline into the behavioral sciences following high school. In some respects, the picture is similar to that for the biomedical sciences, but more extreme. The initial numbers of freshmen expressing interest in majoring in a behavioral science are considerably greater than for biomedical fields, but their retention rate is much lower. The differential attrition continues until the point of awarding doctorates, by which time the initially large numeric difference between the two fields has become trivial. At this point, furthermore, a substantial fraction of new biomedical Ph.D.s go on to a period of postdoctoral training. Very few behavioral scientists do postdoctoral work, and their numbers are not increasing materially, despite the recommendations of earlier committees.

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[7] Exact numbers are not available.

[8] The numbers used in Figure 1-2 are taken from Appendix Table 3-1 in Volume II of this report and are averages over several years. The attrition rate may in fact be due in part to a lengthening of the time spent in graduate study. Nonetheless, even if this is taken into account, the attrition rate for biomedical scientists is very high and points to the possibility that either selection processes or retention efforts could be improved in order to enhance the efficiency of the system and to increase productivity.

[9] Very little information is available about the extent to which trainees leave the postdoctoral training pool to pursue different careers in or out of science. The imbalance between inputs and outputs cannot be taken as projecting the growth rate of the pool, since to some extent the discrepancies reflect the varying quality of information available for analysis.

## THE STRUCTURE OF NRSA TRAINING PROGRAMS

The National Research Service Act (NRSA) supports a great variety of training activities, all fields of biomedical and behavioral sciences, as well as interdisciplinary programs related to specific disease problems and health services research. This training is available at many points in the education pipeline: to some undergraduate students, graduate students studying for their Ph.D.s, postdoctoral students, and persons who have already received an M.D. or other professional degree. In addition, the Medical Scientist Training Program (MSTP) supports courses of study leading to a combined M.D./Ph.D. degree. The Minority Access to Research Careers (MARC) program is designed to increase minority participation in research.

Training grants and fellowships are the principal vehicles used by public agencies to influence the production of Ph.D. and M.D. biomedical and behavioral scientists. Almost all of the institutes at NIH/ADAMHA support training through one or both vehicles, each program having been created in response to a perceived national need. Awards are made on the basis of national competition and the responsiveness of proposals to criteria established by the granting agency.

The overall goals of these biomedical and behavioral training programs are threefold:

1. to provide for a *supply* of personnel sufficient to meet demand;
2. to ensure that their *quality* is high enough to carry on increasingly sophisticated biomedical and behavioral research; and
3. to make sure that the pool of *skills* responds to shifts in demand for various kinds of specialized personnel.

To reach these goals, a number of mechanisms are employed, the adoption of which is based on assumptions (explicit or implicit) concerning how occupational choices are made, how biomedical and behavioral research skills are acquired, and what the market will be for personnel having such skills. (Chapter 4 provides an extended discussion of the goals, mechanisms, and outcomes of these training programs.) The two major activities supported by NRSA are training grants and fellowships.

### Training Grants

Institutional training grants are awarded to academic departments and programs rather than to individuals. The peer review groups examine the training plan, but the trainees are selected by the training institution. While each training grant award can be perceived to be unique, major differences exist between those provided to support graduate education and training and those supporting postdoctoral education.

**Predoctoral Training Grants**: Covering tuition and a small factor of support to the training group, these grants are awarded mainly by the National Institute of General Medical Sciences (NIGMS) in a number of interdisciplinary and disciplinary fields, based on an intensive review of the quality of the existing academic graduate program of the applicant department and institution.[10] The size of the applicant pool and the field of students accepting admissions are taken into account. The purpose of predoctoral training grants is to increase the capacity of a preexisting program to train biomedical or behavioral scientists.

The success of the program is judged by peer reviewers, using such measures as diversity of course offerings, quality of the instructional group, academic standards of the group, flexibility in terms of the development of dissertation projects, time required for students to obtain a degree, success of students in accomplishing high-quality research, and the success of former students in obtaining either postdoctoral appointments in leading laboratories or first independent appointments in research universities and institutions. Reviewers also make judgments about commitment of financial and other support to the academic effort, and they usually attempt to ensure that a training grant will increase the number of trainees to the program. In some cases the award of training grants is used to leverage additional institutional support for the program.

**Postdoctoral Training Grants**: Training grant awards for postdoctorates tend to focus more directly on research experience. Criteria similar to those for predoctoral grants are used in making postdoctoral awards in the basic biomedical and behavioral areas, although they are less commonly applied to clinical science training awards (see below). In every case, however, careful judgments are made about the quality of the training staff and their research productivity. Training grant programs account for about 76 percent of NRSA training positions funded through NIH/ADAMHA.

### Fellowships

Awarded on an individual basis--mostly to postdoctorates who, together with a specific research sponsor, proposed a research project to be pursued if an award is made--fellowships are given in response to the research accomplishments of the fellow and the mentor. Most fellows seeking postdoctoral awards have already had successful careers as graduate students and can demonstrate a capacity for original research; that, together with the quality of the proposed project, determines success in obtaining the award. In a sense, research fellowship awards are small research grants, but they provide recognition and support for outstanding young scientists at an early point in their careers.[11] Fellowships account for 17 percent of NRSA-supported positions funded through NIH/ADAMHA.

### NRSA Training for Physician/Scientists

Fifty years ago, a physician/scientist was an individual engaged in research at the bedside or in the clinic, observing cause and effect in the human model: a substance given or withheld, and a result measured. The past several decades, however, have seen a shift in emphasis from the clinic to the biochemical laboratory, where investigations are conducted at the cellular level. For purposes of definition, therefore, the "physician/scientist" referred to throughout this report is one who has earned the M.D. degree, has had additional training or experience in the basic sciences or held clinical fellowships, and has spent varying proportions of his or her time in both scientific investigation and clinical practice.

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[10] Included in the review are evaluations of mentors' success in previous training of research scientists, obtaining and sustaining research support from granting agencies, publications, citations, prizes and awards, and stature in the field. Evaluation of potential trainees is based on their grade-point averages, test scores, baccalaureate institution, and undergraduate research experience. Also assessed are physical facilities, institutional commitment, and existing financial support for the program.

[11] In addition to NRSA-supported training, NIH and ADAMHA support other programs for advanced research training. Of particular importance in this series is the Physician/Scientist Training Program, which supports researchers over a five-year period, beginning at the career stage traditionally spent in postdoctoral research training.

NRSA currently supports several types of physician/scientist training programs, including the Medical Scientist Training Programs (MSTP) leading to the M.D./Ph.D. degree, institutional training grants, and other special fellowships. Because of their formal curriculum, firmly grounded in the basic sciences, MSTP and Physician/Scientist Award Program have an assumed advantage, in terms of scientific training, over the traditional institutional training grant conducted in the subspecialty divisions of clinical departments. This superiority can only be assumed, however, because of a lack of substantive evaluations of these programs (see Chapter 4).

## A STATISTICAL OVERVIEW OF NRSA TRAINING PROGRAMS

This section focuses on NRSA programs administered by NIH and by ADAMHA.[12] It describes the current size and budget of the various program components; it also provides an historical overview of NRSA training. The definition of NRSA training used here is the trainee ("T" programs) and fellowship ("F" programs) support programs for predoctoral and postdoctoral students funded under NRSA. In addition, a discussion of non-NRSA research training is included.

### NRSA Training Programs in FY 1987

In FY 1987, NIH and ADAMHA supported a total of 11,242 NRSA full-time equivalent positions (FTEP).[13] These positions were divided into the following basic types of NIH and ADAMHA research training programs: predoctoral and postdoctoral traineeships, predoctoral and postdoctoral fellowships, and short-term training (Table 1-1).

**Traineeships**: Training grants are awarded to institutions, usually to academic departments, rather than individuals. While the grant applications by the institutions are subject to peer review, selection of both predoctoral and postdoctoral trainees is controlled by the institution receiving the grant. Programs are designated in the NIH data system by "activity codes;" all traineeship programs have an NIH activity code beginning with "T." In 1987, FTEP traineeships accounted for 76 percent of all NIH and ADAMHA training positions. The $192.1 million spent on institutional awards in 1987 represented 80 percent of the $238.8 million total awarded for research training within NIH.[14]

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[12] The Health Research Services Administration (HRSA) is the only other agency that provides NRSA support to students. In FY 1989, HRSA supported 69 trainees and 8 fellows. Data for HRSA are not included in the above analysis.

[13] Training positions are defined in terms of full-time equivalent positions (FTEP), i.e., the number of positions during the year calculated as if each trainee/fellow was employed for 12 months (three months for short-term training). The actual number of individuals supported was higher than the number of positions. FTEP data were computed from the NIH Trainee/Fellow File (TFF) by the National Research Council and differ from the number of appointments as reported in the *NIH Data Book 1988*.

[14] *NIH Data Book 1988*, Table 16.

Table 1-1. 1987 NRSA Training by Field, Agency, and Definition

| | Full-Time Equivalent Training Positions | | | Estimated Training Appointments | | |
|---|---|---|---|---|---|---|
| BIOMEDICAL | TOTAL | NIH | ADAMHA | TOTAL | NIH | ADAMHA |
| Total | 7388 | 7009 | 379 | 8436 | 7961 | 475 |
| Predoctoral | 3681 | 3499 | 182 | 4268 | 4041 | 228 |
| Fellow | 86 | 67 | 19 | 95 | 71 | 24 |
| Trainee | 3594 | 3431 | 163 | 4173 | 3969 | 204 |
| Postdoctoral | 3707 | 3510 | 197 | 4167 | 3920 | 247 |
| Fellow | 1580 | 1531 | 49 | 1692 | 1631 | 61 |
| Trainee | 2127 | 1979 | 148 | 2475 | 2289 | 185 |
| BEHAVIORAL | TOTAL | NIH | ADAMHA | TOTAL | NIH | ADAMHA |
| Total | 924 | 402 | 522 | 1112 | 457 | 655 |
| Predoctoral | 504 | 250 | 254 | 604 | 285 | 319 |
| Fellow | 37 | 35 | 2 | 40 | 37 | 3 |
| Trainee | 467 | 214 | 253 | 564 | 248 | 317 |
| Postdoctoral | 420 | 152 | 268 | 508 | 172 | 336 |
| Fellow | 95 | 25 | 70 | 114 | 27 | 88 |
| Trainee | 324 | 126 | 198 | 394 | 146 | 248 |
| CLINICAL | TOTAL | NIH | ADAMHA | TOTAL | NIH | ADAMHA |
| Total | 2157 | 2080 | 77 | 2493 | 2397 | 96 |
| Predoctoral | 654 | 638 | 16 | 758 | 738 | 20 |
| Fellow | 17 | 1 | 16 | 21 | 1 | 20 |
| Trainee | 637 | 637 | 0 | 737 | 737 | 0 |
| Postdoctoral | 1503 | 1442 | 61 | 1735 | 1659 | 76 |
| Fellow | 113 | 102 | 11 | 122 | 109 | 14 |
| Trainee | 1390 | 1340 | 50 | 1613 | 1550 | 63 |
| TOTAL | TOTAL | NIH | ADAMHA | TOTAL | NIH | ADAMHA |
| Total | 10469 | 9491 | 978 | 12041 | 10815 | 1226 |
| Predoctoral | 4839 | 4387 | 452 | 5631 | 5063 | 567 |
| Fellow | 140 | 103 | 37 | 156 | 110 | 46 |
| Trainee | 4698 | 4282 | 416 | 5475 | 4954 | 521 |
| Postdoctoral | 5630 | 5104 | 526 | 6410 | 5752 | 659 |
| Fellow | 1788 | 1658 | 130 | 1929 | 1766 | 163 |
| Trainee | 3841 | 3445 | 396 | 4481 | 3985 | 496 |
| T35 Short-Term Training (not included in above figures) | | | | | | |
| Total | 774 | 752 | 22 | 774 | 752 | 22 |
| Grand Total | 11243 | 11243 | 1000 | 12815 | 11567 | 1248 |

NOTE: Totals may not add due to rounding. Full-time equivalent estimates are in term of trainee/fellow years, i.e., one trainee/fellow for 12 months. Actual appointments are higher due to partial year awards. Appointments are consistent with reported training figures published in the NIH Data Book 1988 and in ADAMHA NRSA Research Training Tables FY 1987. Field of trainee/fellows determined by degree/specialty/field data on individual trainee/fellow record (Form 2271).

SOURCE: Estimated by National Research Council from the NIH Trainee Fellow File.

Table 1-2 shows that the T32 program (institutional training grants) is the largest single training effort within NIH/ADAMHA. In 1987, there were 4,347 predoctoral and 3,824 postdoctoral positions in the T32 program, comprising 72.7 percent of the total NIH/ADAMHA training effort of 11,242 positions. The stated purpose of the T32 program is "to help ensure that highly trained scientific manpower will be available in adequate numbers and in the appropriate research areas and fields for the nation's biomedical and behavioral research agenda."[15] T32 trainees are required to devote at least 40 hours per week to research training and must be citizens or have permanent visas. Prior to appointment, trainees must sign a "payback" agreement, by which they agree to engage in biomedical/behavioral research and/or teaching for a period equal to the T32 support period in excess of 12 months. If trainees do not begin to carry out this requirement within two years of NRSA program termination, they are required to return the support funds to the federal government. Stipends are currently $8,500 per annum for predoctoral students and range from $17,000 to $31,500 per annum for postdoctoral students, depending upon experience. Appointments are made for 12 months; no trainee may receive more than five years of aggregate NRSA predoctoral support and three years of aggregate postdoctoral support without a special waiver. A significant subset of the T32 program is the Medical Scientist Training Program (MSTP), which provides training in biological, chemical, physical, and social sciences, combined with medical training, and leads to a joint M.D./Ph.D. degree. In FY 1987 the MSTP program was composed of 636 FTEP positions, or 14.7 percent of the total T32 predoctoral FTEPs, or 4,347.[16] All of the MSTP positions were in clinical science.

The T34 Minority Access to Research Careers (MARC) program is somewhat unusual in that it is aimed at undergraduates. MARC is one of several NIH/ADAMHA programs designed to increase the numbers and capabilities of biomedical and behavioral scientists from underrepresented minorities. In addition to student support, the T34 program provides funds for consultants, personnel, staff travel, and research equipment and supplies. The program also allows trainees to undertake special work at major research universities and laboratories during summer sessions.

The T35 program (774 positions in FY 1987) is intended for short-term training. Although it can provide support to postdoctorates, it is designed as a vehicle to introduce students in health professional schools to a research career and/or research in an area of national need. In this program trainees usually are funded for only three months during their summer term or during an off quarter.[17]

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[15] See National Institutes of Health, "National Research Service Award Grants (T32)," mimeographed supplement to be used with T32 grant application, April 1989, p. 1.

[16] In addition to the MSTP program at the National Institute of General Medical Sciences (NIGMS), the National Institute of Neurological and Communicative Disorders and Strokes (NINCDS) has designed a program under the T32 umbrella that is specifically aimed at short-term training of M.D.s. This program is thus run as a *de facto* T35 short-term training program; NINCDS feels that M.D.s who receive exposure to research through this mechanism are more likely to pursue research careers.

[17] The National Heart, Lung and Blood Institute (NHLBI) runs a Minority Hypertension program within the T35 program that is not research training in the traditional T35 sense. These positions in NHLBI, numbering 404 in 1987, have been excluded from the data presented here. ADAMHA supported 22 of the T35 positions; the remaining 752 were supported by NIH.

TABLE 1-2. NIH/ADAMHA NRSA Training Program Description (T Programs)

| Activity Code | Program Description | Type | 1987 Program Size (FTEP Awards) |  |  |  | 1987 Program Cost (Annualized Direct Cost per Trainee) |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Biomedical | Behavioral | Clinical | Total | Biomedical | Behavioral | Clinical |
| T15 | Continuing education grants to assist professional schools and other institutions (e.g., continuation, extension, refresher education in new science in the profession) | Postdoc | 10 |  | 8 | 18 | $31,141 |  | $32,000 |
| T32 | Institutional grants to enable institutions to award NRSA support to individuals selected by the institution; study in selected "shortage" areas | Predoc | 3,265 | 446 | 636 | 4,347 | $12,915 | $11,443 | $15,407 |
|  |  | Postdoc | 2,118 | 324 | 1,382 | 3,824 | $21,899 | $21,069 | $26,253 |
|  |  | Total | 5,383 | 770 | 2,018 | 8,171 |  |  |  |
| T34 | MARC undergraduate institutional grants to enable minority institutions to award support to individuals selected by the institution for undergraduate research in biomedical and behavioral sciences | Undergrad | 329 | 21 | 1 | 351 | $8,258 | $7,654 | $10,504 |
| T35 | NRSA short-term training to provide individuals with research training in summer or off quarters to encourage research careers in areas of national need | Total |  |  |  | 774 |  |  | $2,383 |
| Total | Note: Total cost data are weighted means and exclude T35 program. | Undergrad | 329 | 21 | 1 | 351 | $8,258 | $7,654 | $10,504 |
|  |  | Predoc | 3,265 | 446 | 636 | 4,347 | $12,915 | $11,443 | $15,407 |
|  |  | Postdoc | 2,118 | 324 | 1,382 | 3,824 | $21,899 | $21,069 | $26,253 |
|  |  | Total | 5,722 | 791 | 2,027 | 8,540 | $16,005 | $15,285 | $22,865 |

NOTE: The number of trainees is calculated in terms of full-time equivalent positions (FTEP); one trainee for 12 months, rather than actual awards. Actual awards include individuals who were in the program for less than 12 months during 1987; awards are approximately 10 percent higher than trainee years. For the T35 short-term program, an FTEP was defined as one trainee for 3 months. Cost data also were normalized for a trainee-year basis (3 months for T35; 12 months for all others). These cost data (from the Trainee Fellow File (TFF)) include stipend, dependency, travel, and tuition. They exclude administrative and some other costs and should not be interpreted as an indication of the total cost of the program.

SOURCE: Calculated by National Research Council from the NIH Trainee Fellow File.

In FY 1986, Ph.D.s comprised 55.4 percent of NIH postdoctoral trainees (down from 63.6 percent in 1980); M.D.s made up the remaining 44.6 percent (up from 36.4 percent).[18]

**Fellowships**: Fellowships are awarded on an individual basis, primarily for postdoctoral study. They are extremely competitive and are awarded on the basis of a thorough review of proposed research with a mentor and sponsoring institution. In 1987 fellows made up 17.2 percent of all training positions, with awards allocated at a cost of $46.6 million, or 19.1 percent, of the NIH/ADAMHA research training budget. Table 1-3 provides a description of the FY 1987 NRSA fellowship programs. The F32 program is clearly the largest; in FY 1987 it supported 78.9 percent of all fellowship positions. The F32 program is designed to provide postdoctoral research training to individuals to broaden their scientific backgrounds and extend their potential for research in specified health-related areas. The F31 program is the predoctoral equivalent of the F32 program: together these two programs supported over 85 percent of NRSA fellows. In 1987, Ph.D.s comprised 85.3 percent of NIH postdoctoral fellowships, while M.D.s made up the remaining 14.7 percent.[19]

**Other NIH Research Training Activities**: In addition to the programs described above, several activities at NIH provide research experience.

- *Career Award Grants*:[20] These awards, made on both an individual and institutional basis, provide up to five years of support for scientists early in their careers. Designed to free recipients from teaching and administrative duties such that they can devote a major effort (at least 80 percent) to research, they are widely considered to be "super-postdoctorals." Indeed, career award grants occupy a somewhat "gray" area between research and training; most individuals who receive career award grants have already proven their ability to do independent research and have embarked upon research careers. These so-called "K" programs are an important source of research experience for promising physician/scientists: as shown in Table 1-4, awards directed toward physicians (K08 and K11) accounted for 90 percent of the total K positions in FY 1987. The K12 and K16 programs are career development institutional grants made to medical schools (K12) and dental schools (K16); the institutions then appoint clinicians for development of individual research skills. In 1987, the K12 program supported approximately 52 scientists at 12 different institutions; the K16 program supported approximately 39 scientists at nine different institutions.

- *R25 Research Grants*: The National Cancer Institute (NCI) administers a program for the training of doctoral students in cancer prevention; providing student laboratory research experience to high school, prebaccalaureate, and predoctoral students; curriculum development in nutrition/cancer prevention;

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[18] See National Institutes of Health, *NIH Data Book 1988*. Washington, D.C.: National Institutes of Health, 1988, Table 39. Degree of postdoctoral trainee data are unavailable from ADAMHA.

[19] *Ibid*. Degree data for ADAMHA fellows are unavailable.

[20] It should be noted that the K programs do not fall under the NRSA program umbrella and are not funded from research training funds.

Table 1-3. NIH/ADAMHA NRSA Fellowship Program Description (F Programs)

| Activity Code | Program Description | Type | 1987 Program Size (FTEP Awards) |  |  |  | 1987 Program Cost (Annualized Direct Cost per Fellow) |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Biomedical | Behavioral | Clinical | Total | Biomedical | Behavioral | Clinical |
| F05<br>F06<br>F15 | International Fellowships. For collaborative research for alien scientists (F05), senior international fellows for U.S.medical school faculty to study abroad (F06), and Fogarty International fellows who spend 3 to 12 months in residence at NIH (F15) | Predoc | 2 |  |  | 2 | $28,895 | $27,994 |  |
|  |  | Postdoc | 153 | 5 |  | 158 | $24,108 | $25,307 |  |
|  |  | Total | 155 | 5 |  | 160 |  |  |  |
| F31 | Predoctoral NRSA fellows for specified research leading to research degree | Predoc | 73 | 37 | 16 | 126 | $12,402 | $10,652 | $8,772 |
|  |  | Postdoc | 0 | 0 | 0 | 0 |  |  |  |
|  |  | Total | 73 | 37 | 16 | 126 |  |  |  |
| F32 | Postdoctoral NRSA fellows for specified research to broaden research background and extend research potential | Predoc | 0 | 0 | 0 | 0 |  |  |  |
|  |  | Postdoc | 1,347 | 83 | 94 | 1,524 | $22,631 | $20,922 | $27,764 |
|  |  | Total | 1,347 | 83 | 94 | 1,524 |  |  |  |
| F33 | NRSA senior fellow awards to provide opportunities for senior scientists to make major changes in careers, e.g., new research training, learning new fields, sabbaticals | Postdoc | 22 |  | 2 | 24 | $32,637 |  | $33,000 |
| F34 | MARC Faculty awards. Fellowships to minority institution faculty for advanced research training | Predoc | 10 |  |  | 10 | $18,955 |  |  |
|  |  | Postdoc | 14 | 1 |  | 15 | $25,593 | $35,000 |  |
|  |  | total | 24 | 1 |  | 25 |  |  |  |
| F35 | Intramural NRSA awards. Support for research training in the NIH intramural program | Predoc | 2 |  | 1 | 3 | $12,808 |  | $32,000 |
|  |  | Postdoc | 45 | 7 | 17 | 69 | $18,511 | $14,430 | $14,800 |
|  |  | Total | 47 | 7 | 18 | 72 |  |  |  |
| Total | Note: total cost data are weighted means | Predoc | 87 | 37 | 17 | 141 | $13,544 | $10,652 | $10,138 |
|  |  | Postdoc | 1,581 | 96 | 113 | 1,790 | $22,822 | $20,824 | $25,906 |
|  |  | Total | 1,668 | 133 | 130 | 1,931 | $22,338 | $17,994 | $23,844 |

NOTE: The number of trainees is calculated in terms of full-time equivalent positions (FTEP); one trainee for 12 months, rather than actual awards. Actual awards include individuals who were in the program for less than 12 months during 1987; awards are approximately 10 percent higher than fellow years. Cost data also were normalized for an FTEP basis. These cost data (from the Trainee Fellow File (TFF)) include stipend, dependency, travel, and tuition. They exclude administrative and some other costs and should not be interpreted as an indication of the total cost of the program.

SOURCE: Calculated by National Research Council from the NIH Trainee Fellow File.

TABLE 1-4. NIH/ADAMHA Career Development Program Description (K Programs)

| Activity Code | Program Description | Type | 1987 Program Size (FTEP Awards) |  |  |  | 1987 Program Cost (Annualized Direct Cost per Trainee) |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Biomedical | Behavioral | Clinical | Total | Biomedical | Behavioral | Clinical |
| K01<br>K02 | Research Scientist Development Award. Supports scientists already committed to research for additional training and research experience | Postdoc | 13 | 5 | 14 | 32 | $55,718 | $56,154 | $69,923 |
| K05 | Research Scientist Award (ADAMHA). Support of a senior scientist in research of his/her sponsoring institution | Postdoc | 8 | 9 | 1 | 18 | $59,517 | $59,328 | $66,317 |
| K06 | Research Career Award enables institutions to fund positions favorable for intellectual growth of investigators of high competence | Postdoc | 30 | 4 | 11 | 45 | $33,064 | $25,671 | $32,539 |
| K08 | Clinical Investigator Award to provide the opportunity for promising medical scientists to to pursue research and fill faculty gaps in shortage areas | Postdoc | 151 | 3 | 268 | 422 | $63,077 | $68,818 | $65,587 |
| K11<br>K12 | Physician Scientist Award. Support newly trained physicians nominated by institution for development of research skills and experience. | Postdoc | 84 |  | 117 | 201 | $64,450 |  | $66,941 |
| K14 | Minority School Faculty Development Award. Encourage faculty investigators at minority schools | Postdoc | 16 | 1 | 1 | 18 | $56,623 | $62,197 | $48,233 |
| K15<br>K16 | Dentist Scientist Award. Similar to K11 for newly trained dentists | Postdoc | 10 | 1 | 7 | 18 | $64,128 | $70,762 | $61,382 |
| Total |  |  | 312 | 23 | 419 | 754 | $57,816 | $51,574 | $64,113 |

NOTE: The number of trainees is calculated in terms of full-time equivalent positions (FTEP); one trainee for 12 months, rather than actual awards. Actual awards include individuals who were in the program for less than 12 months during 1987. K04 and K07 were excluded since these programs are not training. Cost data (from the Consolidated Grant Applicant File) contain only direct cost. They should not be interpreted as an indication of the total cost of the program.

SOURCE: Calculated by National Research Council from the NIH Consolidated Grant Applicant File.

and T35-like training programs. In FY 1988 NCI supported approximately 400 students in the laboratory research experience part of this program.[21]

- *Minority Biomedical Research Support (MBRS)*: This program was established in 1971 to provide salaries in order to enable minority students and faculty to acquire laboratory research experience by working on their own research projects while assisting on faculty projects. The program was funded at $39 million in 1988 and involved 100 minority institutions.[22] In 1988 the MBRS program supported 772 faculty, 1,095 undergraduate students, and 407 graduate students.[23]

- *Research Assistants (RAs) on NIH Research Grants*: A large volume of training occurs when graduate students gain experience and knowledge through their work as RAs to faculty on research grants. NIH research grants to faculty in graduate institutions therefore serve a twofold function: expanding the biomedical/behavioral knowledge base and providing research training. Given that research and development (R&D) grants have been growing at almost twice the rate of research training expenditures for the 1978-1987 period, the role of RAs in the NIH training enterprise may also have been growing in relative importance.[24] Graduate departments in the biological sciences indicated that 4,426 full-time graduate students were supported as RAs on NIH projects in 1987; this represented a 6.5 percent annual growth rate over the 2,673 NIH-supported RAs in 1979.[25] In psychology, NIH supported 334 RAs in 1979 and 382 in 1987.

## GRANT APPLICATIONS AND AWARDS BY TRAINEES/FELLOWS

One indicator of the success of a training program is the ability of former trainees/fellows to obtain research grants.[26] Figure 1-3 presents 1987 percentages of postdoctoral trainees/fellows who have received NIH research grants (R01 activity code) since the scientists began NRSA research training in 1982. The committee was particularly struck by the fact that Ph.D. trainees received R01 grants at approximately three times the rate of M.D.s (10.3 percent versus 3.7 percent); for fellows, the comparable figures are 12.5 percent of M.D.s and 16.2 percent of Ph.D.s. Almost the same proportion of M.D. fellows (28.3 percent) applied for R01 grants, as did Ph.D. fellows (28.5 percent).

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[21] This information was provided from a personal communication with Vincent Cairoli of NCI, August 1989.

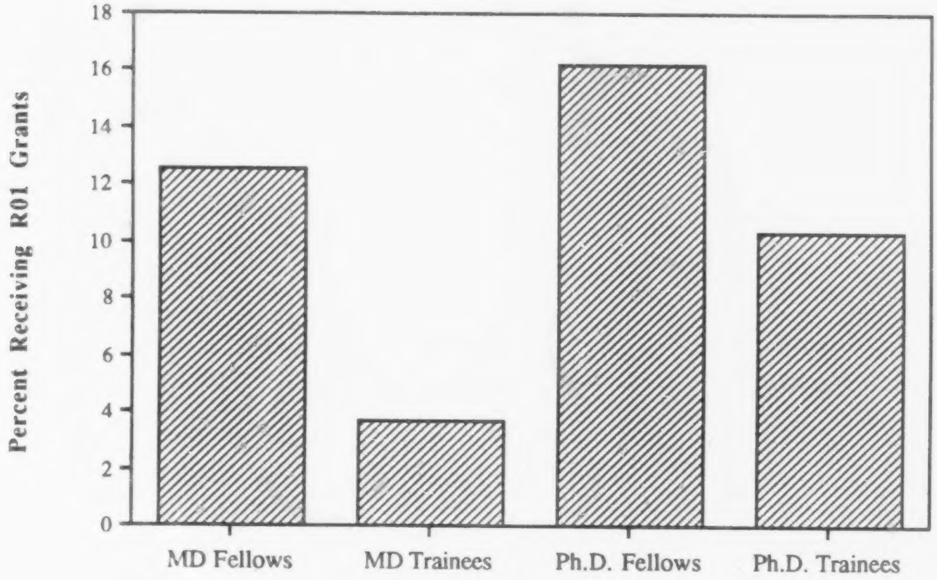
[22] See Michael Fluharty, "Recruiting Minority Students For the Biomedical Sciences," *The Chronicle of Higher Education*, July 12, 1989, p. B3.

[23] Data supplied by Ciraco Gonzales, Division of Research Resources, NIH, August 25, 1989.

[24] Total NIH R&D grants and contracts increased from $2.1 billion in 1978 to $4.9 billion in 1987 (10.0 percent annually); NIH research training expenditures increased from $148.5 to $238.8 million (5.4 percent annually) during the same period. See National Institutes of Health, *NIH Data Book 1988*, Table 16.

[25] These data are from the survey of graduate departments sponsored by the National Science Foundation and NIH, "Survey of Graduate Science and Engineering Students and Postdoctorates" (GSESP).

[26] See Chapter 4 for a discussion of NRSA program evaluation.



SOURCE: Appendix Table A-7.

**Figure 1-3.** Percent of NRSA postdoctoral trainees/fellows who received an R01 grant within five years after initiation of NRSA research training.

However, the difference is much larger for trainees: only 8.5 percent of M.D. trainees who began NRSA research training in 1982 applied for R01 grants, compared to 20.3 percent of the Ph.D. trainees.

## HISTORICAL TRENDS

Table 1-5 contains FTEP data for the period 1978-1987 for NIH/ADAMHA NRSA training and fellowship programs. Estimates in Table 1-5 differ substantially from previous committee estimates of NRSA support levels.[27] There are several reasons for this difference:

1. The data in this report are based on the Trainee Fellow File (TFF) compiled from the records of individual trainees (Form 2271). Data in previous committee reports were based upon the Information for Management, Planning, Analysis and Coordination (IMPAC) file, which is compiled from grant applications by institutions that cover several traineeship positions, and are based upon proposed levels of support rather than actual level of support.

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[27] See, for example, Institute of Medicine, *Personnel Needs and Training for Biomedical and Behavioral Research*, Washington, D.C.: National Academy Press, 1985, Tables 1.3 and 1.4.

Table 1-5. Historical Trends in NRSA Training Positions, 1978-1987

| | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|---|---|---|---|---|
| Biomedical | 6685 | 7181 | 8362 | 7781 | 7842 | 7670 | 7820 | 7741 | 7808 | 7388 |
| Predoctoral | 3735 | 3974 | 4153 | 3767 | 4205 | 4021 | 3997 | 4008 | 3856 | 3681 |
| Fellow | 33 | 50 | 36 | 20 | 42 | 52 | 56 | 92 | 93 | 86 |
| Trainee | 3702 | 3924 | 4117 | 3746 | 4164 | 3969 | 3941 | 3916 | 3762 | 3594 |
| Postdoctoral | 2950 | 3207 | 4209 | 4014 | 3637 | 3649 | 3823 | 3733 | 3952 | 3707 |
| Fellow | 1676 | 1635 | 2214 | 1981 | 1505 | 1596 | 1727 | 1628 | 1817 | 1580 |
| Trainee | 1275 | 1572 | 1995 | 2033 | 2132 | 2053 | 2096 | 2106 | 2135 | 2127 |
| Behavioral | 692 | 733 | 619 | 484 | 1122 | 1012 | 966 | 971 | 962 | 924 |
| Predoctoral | 489 | 483 | 327 | 290 | 763 | 603 | 536 | 530 | 515 | 504 |
| Fellow | 107 | 95 | 58 | 30 | 49 | 31 | 20 | 40 | 33 | 37 |
| Trainee | 382 | 388 | 270 | 260 | 713 | 573 | 516 | 490 | 482 | 467 |
| Postdoctoral | 203 | 250 | 292 | 194 | 359 | 409 | 430 | 441 | 447 | 420 |
| Fellow | 163 | 166 | 188 | 93 | 95 | 114 | 92 | 91 | 91 | 95 |
| Trainee | 39 | 84 | 105 | 101 | 264 | 294 | 339 | 356 | 356 | 324 |
| Clinical | 2356 | 2406 | 1943 | 1939 | 2100 | 2143 | 2205 | 2195 | 2229 | 2157 |
| Predoctoral | 733 | 764 | 674 | 655 | 680 | 653 | 651 | 632 | 687 | 654 |
| Fellow | 3 | 1 | 1 | 1 | 3 | 3 | 6 | 2 | 6 | 17 |
| Trainee | 730 | 763 | 674 | 654 | 677 | 650 | 645 | 630 | 681 | 637 |
| MSTP | 462 | 547 | 646 | 652 | 676 | 646 | 645 | 629 | 661 | 636 |
| Other | 269 | 216 | 28 | 2 | 1 | 4 | 0 | 1 | 20 | 1 |
| Postdoctoral | 1623 | 1642 | 1269 | 1284 | 1420 | 1490 | 1554 | 1563 | 1542 | 1503 |
| Fellow | 318 | 330 | 197 | 226 | 195 | 151 | 184 | 181 | 139 | 113 |
| Trainee | 1305 | 1312 | 1072 | 1057 | 1225 | 1339 | 1370 | 1382 | 1403 | 1390 |
| Total | 9733 | 10320 | 10925 | 10204 | 11064 | 10824 | 10991 | 10908 | 10999 | 10468 |
| Predoctoral | 4958 | 5221 | 5155 | 4712 | 5648 | 5277 | 5184 | 5171 | 5058 | 4839 |
| Fellow | 143 | 147 | 95 | 52 | 94 | 85 | 81 | 135 | 132 | 141 |
| Trainee | 4815 | 5074 | 5060 | 4660 | 5554 | 5192 | 5103 | 5036 | 4925 | 4698 |
| Postdoctoral | 4775 | 5099 | 5770 | 5492 | 5416 | 5547 | 5807 | 5737 | 5941 | 5629 |
| Fellow | 2157 | 2131 | 2599 | 2300 | 1795 | 1861 | 2002 | 1899 | 2047 | 1788 |
| Trainee | 2619 | 2967 | 3171 | 3192 | 3621 | 3686 | 3805 | 3838 | 3894 | 3841 |
| T35 Short-Term Training Total | NA | NA | 573 | 836 | 902 | 1009 | 1029 | 900 | 730 | 774 |

NOTE: Totals may not add due to rounding. Table includes ADAMHA NRSA positions. Estimates are in terms of trainee/fellow years, i.e., one trainee/fellow for 12 months. Actual number of awards to individuals are higher due to partial-year awards. Field of trainee/fellows determined by degree/specialty/field data on individual trainee/fellow records (Form 2271). T35 program estimates are in number of awards and exclude T35 nontraining awards under the NHLBI T35 Minority Hypertension program. MSTP program is a subset of total predoctoral training for a joint Ph.D.-M.D. degree.

SOURCE: Estimated by National Research Council from the NIH Trainee Fellow File. For T35 program, data are from NIH Data Book 1988, Table 39; estimates of NHLBI T35 are estimated by National Research Council from the NIH Consolidated Grant Applicant File.

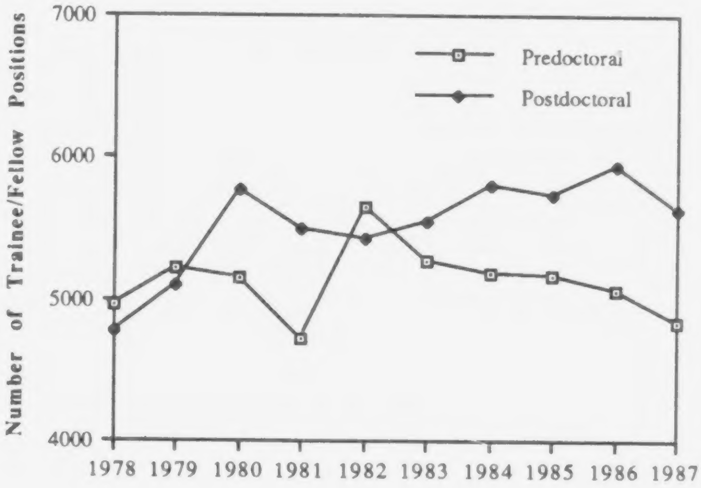
2. NIH constantly revises its files as information is updated. Estimates for earlier years (1984, for example) may change several times as these revisions occur. The data presented here are the most recent (August 1989) estimates available to the committee.

3. The estimates by field in this report are based on the degree/specialty/field code on the TFF. Earlier committee data were estimates of fields compiled from special tabulations developed by the NIH Division of Research Grants. In addition, the Consolidated Grant Applicant File (CGAF) records a single discipline code for all trainees, regardless of their actual field, whereas the TFF data reported here are based upon actual fields of the trainees.[28]

Figure 1-4 illustrates trends in predoctoral and postdoctoral FTEP support for the period 1978-1987. These are full-term (i.e., excluding T35) T and F program totals. Total years of support for postdoctoral positions have been increasing since the early 1980s, while predoctoral support has been declining. Total FTEP trainee/fellow support under the NRSA program peaked in 1982 at 11,063 positions and, after remaining near that level for four years, declined to 10,468 positions in 1987.

Figure 1-5 breaks out the number of FTEP positions supported in the biomedical sciences. Predoctoral positions have declined from a peak of approximately 4,200 in 1982 to approximately 3,700 FTEP in 1987. Postdoctoral positions have oscillated in the range 3,700-4,000 since 1984. Biomedical sciences have dominated the NRSA program historically, with 70.6 percent of all positions in 1987.

Figure 1-6 illustrates trends in trainee/fellow FTEP positions in the behavioral sciences. Predoctoral positions grew rapidly in 1982, but have since fallen off to about 500 positions. Postdoctorals in the behavioral sciences increased steadily from 194 FTEP in 1981 to a high of 447 positions in 1986. Behavioral science predoctoral support has remained around 10 percent of total NRSA predoctoral support for the 1978-1987 period; behavioral postdoctorals have increased proportionally during this period, from 4.3 percent in 1978 to 7.5 percent in 1987.



SOURCE: Table 1-5.

**Figure 1-4.** Total NIH/ADAMHA NRSA predoctoral and postdoctoral positions supported, 1978-1987.

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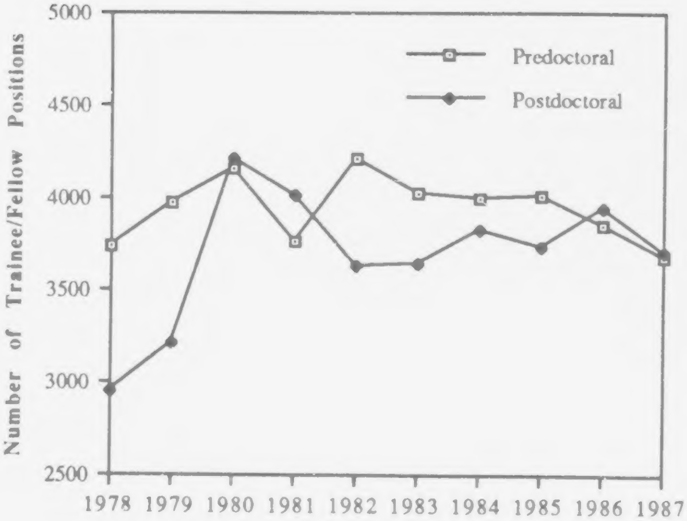
[28] The disaggregation of trainees/fellows into fields is considered by some within NIH as an impossible task because of differences across institutes in program administration and definitions. The accuracy of these data is unknown. In the committee's opinion, improvement in the field classification of trainees/fellows is needed in the overall NRSA data base (see Chapter 5).

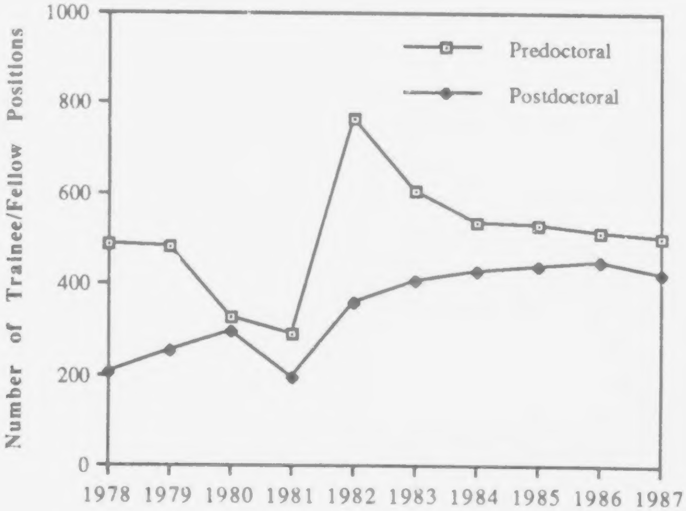
Figure 1-7 displays trend data on clinical sciences trainee/fellow FTEP positions for the period 1978-1987. Predoctoral support in the clinical sciences has remained flat, at approximately 650 positions since 1980; postdoctoral support increased initially, but flattened out at approximately 1,500 positions annually in 1983. Proportional support in the clinical sciences has been declining, from 14.8 percent to 13.5 percent of total NRSA predoctoral and from 34.0 percent to 26.6 percent of postdoctoral support during the 1978-1987 period.

The MSTP program has shown a fairly constant level of support during the 1980s at approximately 650 positions annually (Table 1-5). Short-term training (T35) grew to a peak of 1,029 in 1984, but the 1987 support in this program was 774 positions.



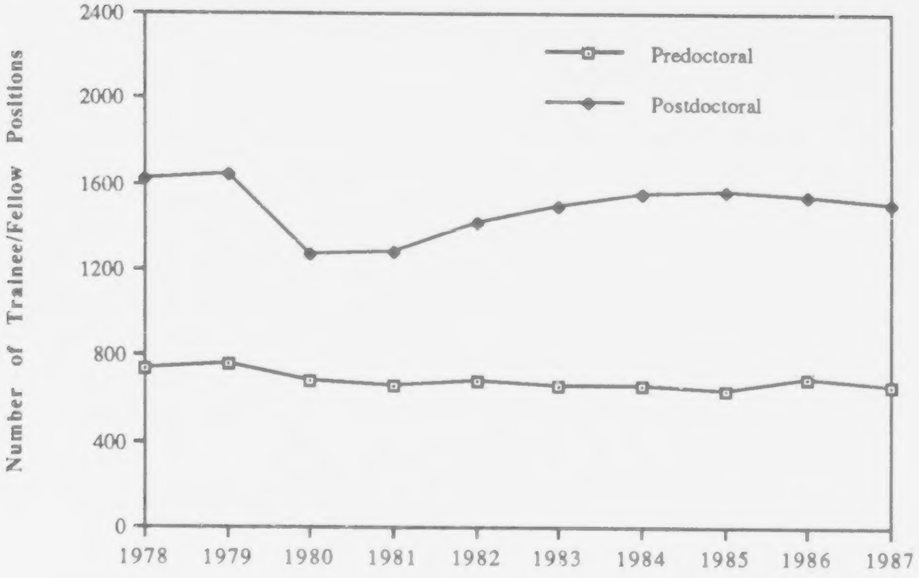
SOURCE: Table 1-5.

**Figure 1-5.** NIH/ADAMHA predoctoral and postdoctoral trainee/fellow positions in the biomedical sciences, 1978-1987.



SOURCE: Table 1-5.

**Figure 1-6.** NIH/ADAMHA NRSA predoctoral and postdoctoral trainee/fellow positions in the behavioral sciences, 1978-1987.



SOURCE: Table 1-5.

**Figure 1-7.** NIH/ADAMHA NRSA predoctoral and postdoctoral trainee/fellow positions in the clinical sciences, 1978-1987.

# CHAPTER 2

# THE CURRENT MARKET FOR BIOMEDICAL AND BEHAVIORAL SCIENTISTS

## OVERVIEW

Labor markets for biomedical and behavioral scientists moved toward a balance between supply and demand in the 1980s after a period of excess supply in the 1970s. Biomedical scientists are in strong demand due to increased employment in industry; increased predoctoral enrollments have not yet produced an adequate supply of new biomedical Ph.D.s. The behavioral sciences have worked off the excess supply of the 1970s through continued employment growth and a decline in the number of new Ph.D.s. There are no reliable data on the supply and demand for physician/scientists.

Despite recent progress, minorities remain underrepresented among Ph.D. recipients and in the total work force of the biomedical and behavioral sciences. Female participation has increased more rapidly than minority participation, particularly by black males. However, many female Ph.D.s are not employed full-time in their scientific fields, with adverse consequences for personnel supply.

Foreign students received only 18 percent of biomedical Ph.D.s and 7 percent of behavioral Ph.D.s in 1988. However, most foreign students do not stay to work in the United States after graduation. Thus, foreign students contribute relatively little to the growth of biomedical and behavioral sciences work force.

## THE CHANGING LABOR MARKET FOR BIOMEDICAL AND BEHAVIORAL SCIENTISTS, 1973-1987

The size and composition of the scientist work force are determined by three flows: *new entrants*, usually new degree recipients; *attrition*, in the form of deaths and retirements; and net gains or losses due to occupational *mobility*. New entrants serve the dual purpose of offsetting attrition and permitting growth. The adequacy of supply of new entrants depends on whether their numbers exceed, equal, or fall short of the replenishment needs and growth needs of the work force. As a result, the accurate measurement of these three processes is basic to any study such as this.

### Refreshment Rates

Figure 2-1 shows the attrition and refreshment rates for biomedical scientists--that is, the number of new Ph.D.s as a percent of those employed in that field.[1] Attrition rates are the percentage losses due to death, retirement, and net mobility.[2] Refreshment minus attrition is the percentage available for growth in employment in the field. In 1974, for example, new Ph.D.s comprised 8.6 percent of total employment in the biomedical sciences, while losses from attrition were 2.6 percent of employment; this left a net of 6.0 percent available for growth in employment of people trained in the field. By 1987, however, refreshment was 5.4 percent, attrition 2.8 percent, and the potential for growth only 2.6 percent. Actual employment growth, 4.1 percent that year, was achieved by drawing new entrants from other fields.

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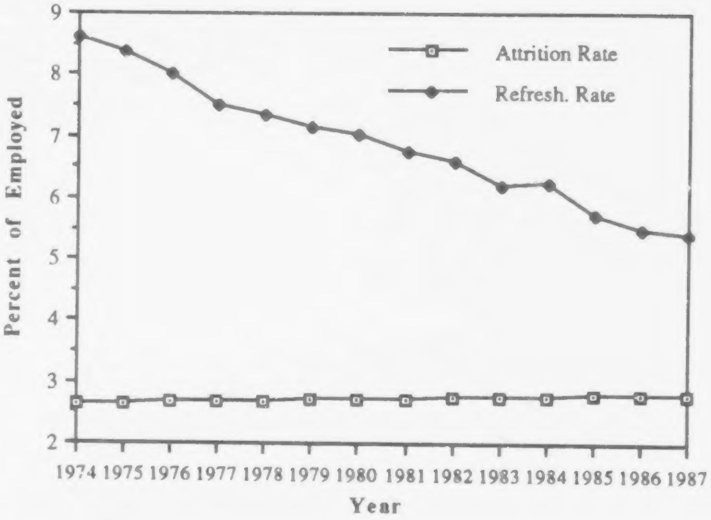
[1] Obviously, not all new Ph.D.s in biomedical science go into the field; also, the field draws Ph.D.s from other areas (e.g., physical sciences, other life sciences) and from foreign scientists. However, the primary supply source of new Ph.D.s is U.S. graduates in the field, and thus the refreshment rate gives one a sense of the historical relationship between this supply source and demand.

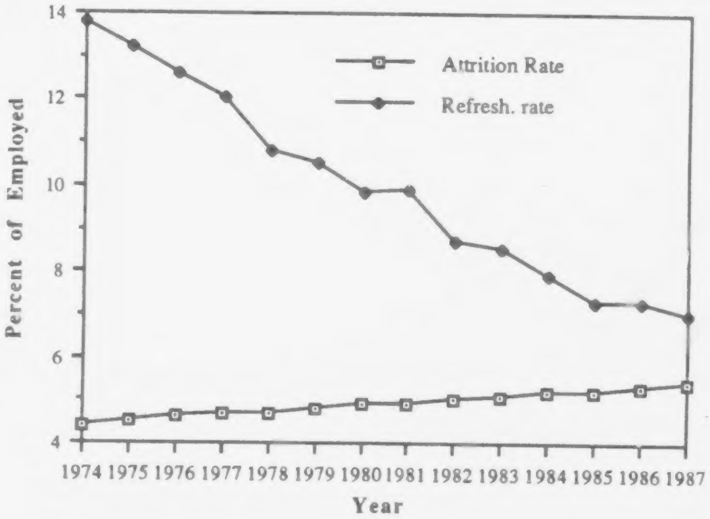
[2] Net mobility is the difference between scientists leaving the biomedical field for other pursuits and scientists entering biomedical science from other employment.



SOURCE: Appendix Table A-8.

**Figure 2-1.** Refreshment and attrition in biomedical science, 1973-1987.

During the 1980s, the biomedical field averaged 4,500 job openings annually (1,080 scientists lost from deaths and retirements, 620 scientists lost from net mobility, and growth requirements of 2,800). Average annual biomedical Ph.D. production during the period was only 3,840. This contrasts sharply with the 1970s, when average annual job openings from all sources were 3,660 and average annual Ph.D. production was 3,520. Clearly, the supply of new biomedical Ph.D.s has begun to fall short of the number of job openings in the late 1980s after an extended period of approximate balance. In the behavioral sciences, on the other hand, new Ph.D.s have exceeded new job openings throughout the 1970s and 1980s.



SOURCE: Appendix Tables A-9 and A-10.

**Figure 2-2.** Refreshment and attrition in nonclinical psychology and other behavioral sciences, 1973-1987.

Figure 2-2 shows that the refreshment rate for behavioral scientists (excluding clinical psychologists) has also been decreasing. In 1973 attrition amounted to 4.4 percent of those employed and refreshment was 13.8 percent, leaving 9.4 percent for growth; actual growth was 8.6 percent. In 1987, attrition was 5.4 percent, and refreshment was 7.0 percent, leaving 1.6 percent for growth; and indeed actual growth was only 1.2 percent.

**Attrition**

Figure 2-3 presents estimates of the rate of exit from the science work force due to death and retirement. These rates increase sharply for scientists over 55 years of age.[3]

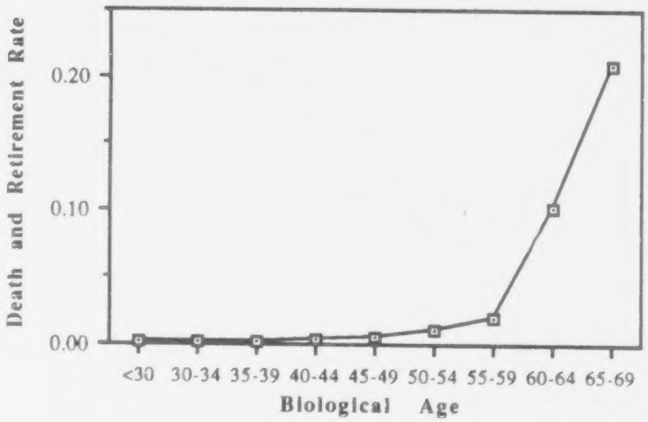
### Net Mobility

Scientists who leave biomedical science for other employment must usually be replaced.[4] Figure 2-4 shows estimates of these net rates of mobility (outmobility less inmobility from other fields) based upon historical data.[5] These exit rates are a function of scientists' "career age" (years since Ph.D. degree); Figure 2-4 shows that the rate increases as a scientist matures.

Obviously, scientists from a wide variety of degree fields (e.g., physical science, behavioral science) work as biomedical scientists. The net mobility rates used here are based on field of employment, regardless of the scientist's degree field. Once scientists gain employment either in a biomedical field or in a nonbiomedical field, they are identified by that employment field rather than their field of degree.

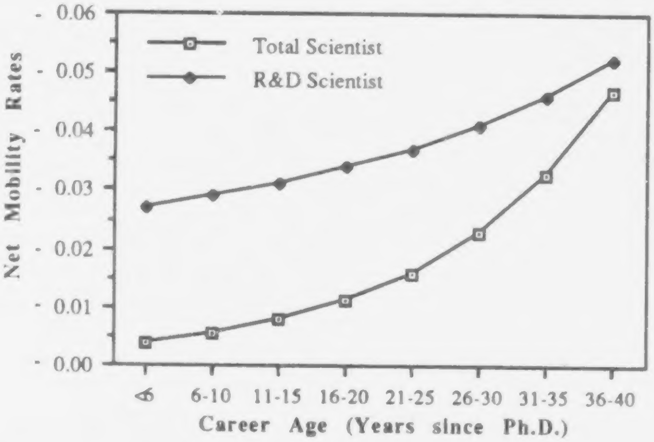
## RECENT TRENDS IN THE LABOR MARKET FOR BIOMEDICAL SCIENTISTS

Figure 2-5 displays patterns of employment for biomedical scientists in 1987 by employment sector and by primary work activity--R&D or



SOURCE: Appendix Table A-16.

**Figure 2-3.** Death and retirement rates for scientific employment.



SOURCE: Calculated from Appendix Table A-17.

**Figure 2-4.** Net mobility rates for total and R&D biomedical scientists by career age.

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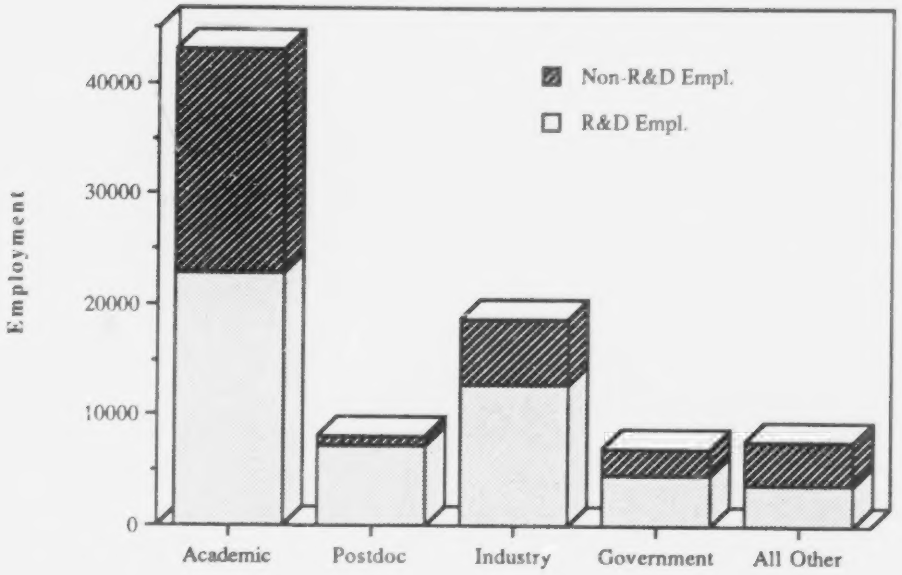
[3] For a more detailed discussion of the model used to estimate scientist attrition, see Joe G. Baker, "Biomedical/Behavioral Cohort Model: A Technical Paper," contained in volume III of this report.

[4] Biomedical scientists are lost from the work force when they move into university administration, industrial management, or other non-science occupations. This loss is partially offset by individuals who move into biomedical science from non-science. The net mobility estimates used here are the difference between these two labor flows.

[5] The rates in Figure 2-4 are for biomedical scientists only; separate rates were computed for behavioral scientists.



SOURCE: Appendix Table A-2.

**Figure 2-5.** 1987 biomedical science Ph.D. employment, by R&D activity and employment sector.

the management of R&D, and non-R&D.[6] An estimated 76,300 Ph.D. scientists identified their work as biomedical science, and another 8,200 were undertaking postdoctoral study in the biomedical sciences. Academic employment (43,000 scientists) and industrial employment (16,000 scientists) were the largest sectors. Overall, 60.5 percent of all biomedical scientists indicated that their primary work activity was R&D or the management of R&D.

### Growth in Employment

Figure 2-6 shows the growth in employment of biomedical scientists between 1973 and 1987. Total employment plus postdoctorates nearly doubled, from 43,000 in 1973 to 84,500 in 1987, an annual rate of growth of 4.9 percent. Industrial employment increased at over twice the rate of academic employment. The proportion of biomedical scientists who indicated that their primary work activity was R&D or the management of R&D also

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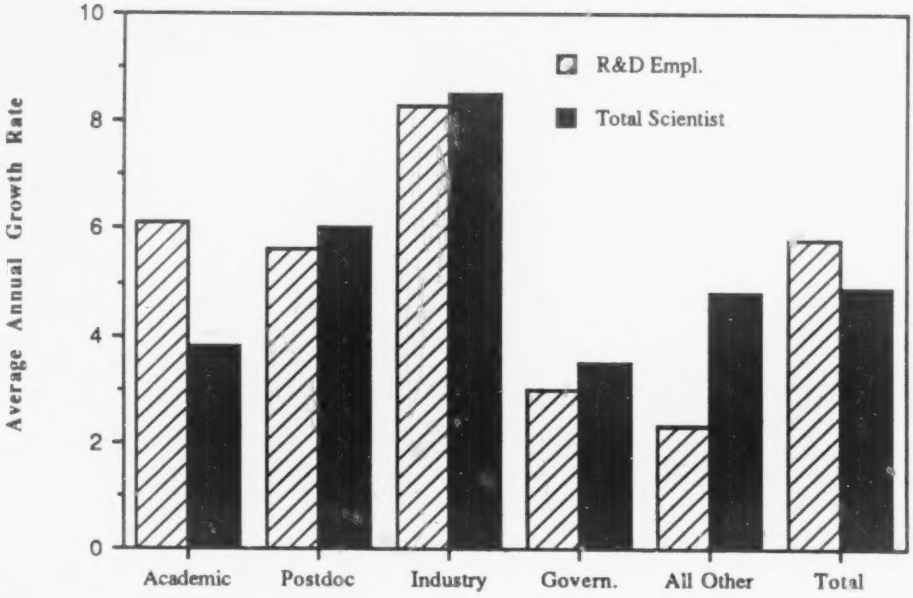
[6] In the Survey of Doctorate Recipients (SDR), respondents are asked to identify their primary work activity. In this report, those respondents who identified their primary work activity as R&D or the management of R&D are classified as R&D scientists; all other scientists are classified as non-R&D scientists. Obviously, some (or most) of these non-R&D scientists devote some portion of their work activity to R&D; however, it is not treated as their primary activity. The R&D/non-R&D dichotomy is used to indicate differences in research intensity among employment sectors and through time.



SOURCE: Appendix Table A-2.

**Figure 2-6.** Average annual growth rates for R&D and total biomedical Ph.D. employment, 1973-1987.

increased during this period, from 53.6 percent in 1973 to 60.5 percent in 1987.[7] This was the result of two basic trends:

1. a growth in the proportion of total employment made up of private industry, in which more than three-fourths of biomedical scientists are engaged in R&D; and
2. an increase in the percentage of academic scientists who indicate that their primary work activity is R&D.

The annual average increase in the number of biomedical scientists engaged in R&D has been 5.8 percent for the 1973-1987 period, slightly higher than overall growth in the field.

**Postdoctoral Appointments**

Figure 2-7 shows that the number of postdoctoral training positions in the biomedical sciences grew rapidly through the 1970s, but has since plateaued near the 1981 level.[8] These trends are consistent with the evidence that new job openings exceeded new Ph.D.s in the late 1980s.

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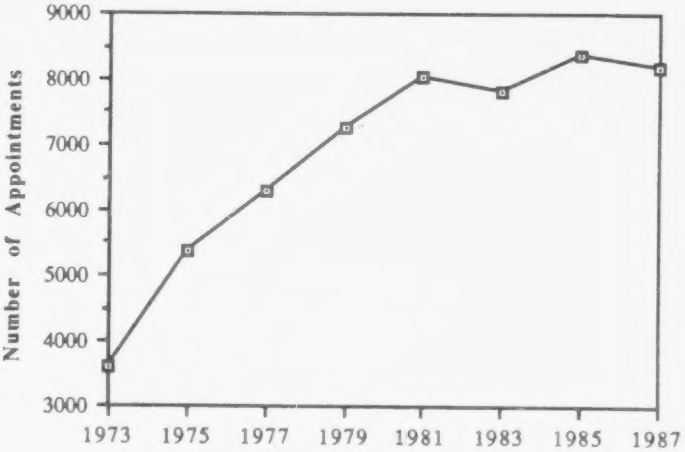
[7] These estimates are from the NAS/NRC, Survey of Doctorate Recipients (SDR).

### Trends in Job Openings and Ph.D. Production

Using the death and retirement rates from Figure 2-3, one can estimate attrition from the work force of biomedical scientists based on age distribution. For the period 1973-1977, deaths and retirements from the stock of biomedical scientists averaged approximately 730 per year. In the later period 1983-1987, the number of annual deaths and retirements averaged 1,200, a 64-percent increase over the earlier period.



SOURCE: Appendix Table A-2.

**Figure 2-7.** Postdoctoral appointments of biomedical scientists, 1973-1987.

For the period 1973-1977, there was a net loss of approximately 450 biomedical scientists per year to other employment. These losses were replaced by new hires. Because of employment growth and changes in the career age distribution, this net migration grew to approximately 670 per year in the period 1983-1987. By the late 1980s, therefore, the need to replace attrition with new Ph.D.s had grown substantially. The aggregate annual attrition of approximately 1,200 consumed one-third of the yearly biomedical Ph.D. production of 3,500 Ph.D.s during the 1973-1979 period. For the period 1979-1987, annual attrition grew to 1,700 and consumed almost half of the annual biomedical Ph.D. output of 3,850.[9] Indeed, at current rates of employment growth and Ph.D. output, attrition replacement will equal new biomedical Ph.D. output by the end of the century.

Figure 2-8 compares the number of job openings by source with the annual production of new biomedical Ph.D.s for the period 1973-1987. It shows a growing gap between supply of and demand for new Ph.D.s. Biomedical science Ph.D. awards totaled 3,520 in 1973; this grew to 3,960 in 1982 and has been relatively flat since then. As a result, there was approximately one job opening per new Ph.D. for the period 1973-1979, but for the period 1979-1987 there were on average 1.17 job openings for each new Ph.D.

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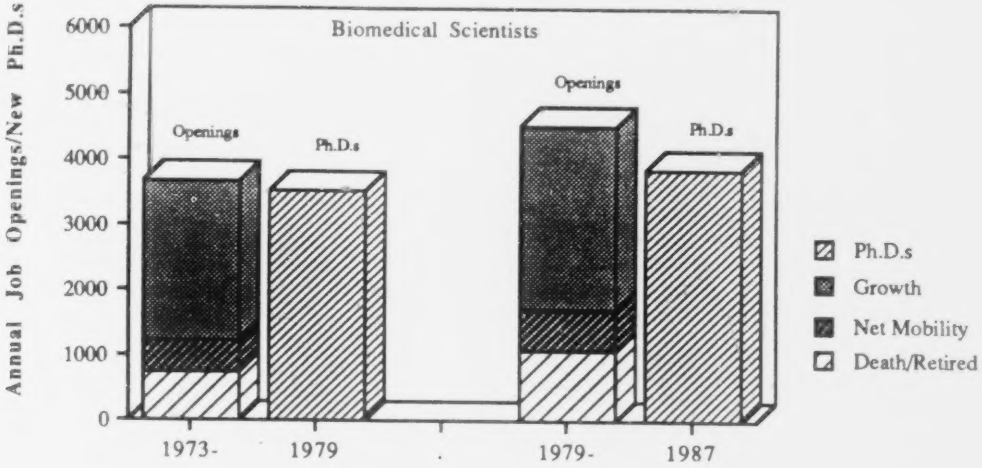
[8] There are two sources of data for postdoctoral appointments in the biomedical sciences: the SDR and the National Institutes of Health/National Science Foundation's Survey of Graduate Science and Engineering Students and Postdoctorates (GSESP). The SDR data are used here.

[9] Because death and retirement are a function of biological age and net mobility is a function of career age, the overall attrition rate of the work force is related to its career and biological age structure. In the 1980s, death and retirement were approximately 1.9 percent per year and net mobility approximately 1 percent per year. See Joe G. Baker, *op cit.*



SOURCE: Appendix Table A-8.

**Figure 2-8.** Average annual job openings and new Ph.D.s in the biomedical sciences, 1973-1979 and 1979-1987.

People and institutions seem to have responded to this imbalance between job openings and new Ph.D.s in the biomedical sciences.[10] Real wages increased for biomedical scientists in the late 1980s, as they did for all Ph.D.s. In response, graduate enrollments in the biomedical sciences (both doctoral and master's levels), which had declined to a low of 41,191 in 1983, have since grown steadily to 44,495 in 1987. First-year graduate enrollments in doctorate-granting institutions have risen from only 8,043 in 1983 to 8,609 in 1987. However, the enrollment response requires several years before numbers of new Ph.D.s are affected.[11]

## RECENT TRENDS IN THE LABOR MARKET FOR BEHAVIORAL SCIENCES

Behavioral scientists are composed of three basic groups according to the NRC nomenclature: *clinical psychologists, nonclinical psychologists*, and *other behavioral scientists* (anthropologists, sociologists, audiologists, and speech pathologists).

### Clinical Psychology

Psychologists, who form the majority of behavioral scientists, have available an alternative to the standard research career pattern. This consists of independent practice in the broad areas of clinical and counseling psychology. Concerned with patient care rather than research, this career path resembles that of the practicing M.D. Doctorates in psychology are usually obtained from university departments, although professional schools of psychology are being accredited to provide doctorates in clinical and counseling fields that are oriented toward service and/or administration.

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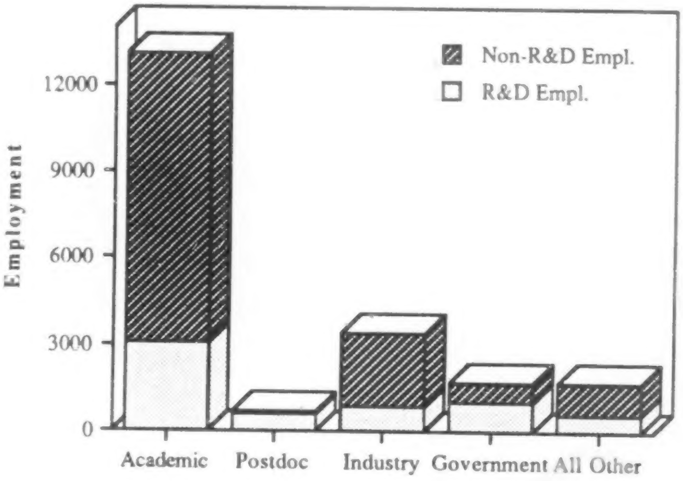
[10] See Joe G. Baker, "The Ph.D. Supply Crisis: A Look at the Biomedical Sciences," paper given at the Western Economics Association Meeting, June 21, 1989, Lake Tahoe, Nevada.

[11] The supply consequences of increasing enrollment were partially offset by increasing time to complete doctoral studies. For a more complete discussion of increasing time to the doctorate, see H. Tuckman, et al., *On Time to the Doctorate*, (Washington, D.C.: National Academy Press, forthcoming. See also Joe G. Baker, "The Ph.D. Supply Crisis."

Only about 1,200 out of a population of 33,388 clinical psychologists (less than 4 percent) are engaged primarily in R&D or the management of R&D. Given the applied nature of clinical psychology, this report focuses on nonclinical psychologists and other behavioral scientists.[12] Nonclinical psychologists usually will be referred to simply as psychologists hereafter.

## Nonclinical Psychology

The market for psychologists is dominated by the academic sector, which employed 63.7 percent of the 1987 total of 20,510 psychologists (Figure 2-9). Industry employed another 16.5 percent, and the remaining 20 percent of employment was scattered across other sectors. In 1987, 29.9 percent of all psychologists indicated that their primary work activity was R&D or the management of R&D.



SOURCE: Appendix Table A-3.

**Figure 2-9.** 1987 Ph.D. Employment of nonclinical psychologists by R&D activity and employment sector.

Industrial employment grew at over twice the rate of the academic sector between 1973 and 1987 (Figure 2-10). Nonclinical psychology degree holders have also been attracted to employment in clinical psychology.[13] Employment of psychologists increased at an annual rate of 3.2 percent from 1973-1987. Postdoctoral appointments in psychology are few compared to biomedical fields, increasing from 259 in 1973 to 666 in 1987.

For the period 1973-1979, an average of 230 psychologists retired or died annually and approximately 430 were lost each year to net mobility. The sum of these two losses--660--represented about 41 percent of annual new nonclinical psychology Ph.D.s (1,591). For the period 1983-1987, attrition from death and retirement grew to 380 annually, and mobility to 540; this aggregate annual attrition of 920 represented 62 percent of average new Ph.D. production of 1,485.[14] As shown in Figure 2-11, there were about 0.7 job openings for each new nonclinical psychology Ph.D. in the period 1973-1979, rising to approximately 0.9 job openings per each new Ph.D. in the period 1979-1987. The labor market of the 1980s for nonclinical psychologists thus seems more in balance, both as a result of increasing openings (primarily from attrition) and a decline in the average number of nonclinical psychology Ph.D.s produced, from 1,591 per year (1973-1979) to 1,485 per year (1979-1987).

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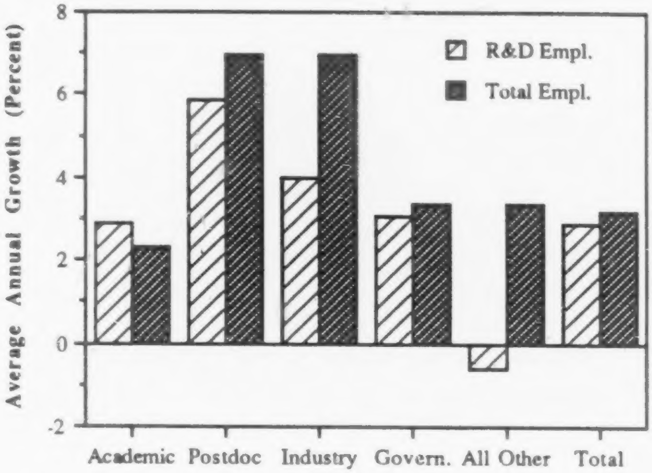
[12] In 1987, an estimated 421 Ph.D.s were doing postdoctoral work in clinical psychology. The employment growth of clinical psychologists was substantial for the 1973-1987 period, averaging 7.9 percent annually; but most of this growth was concentrated in the practice sector (where fewer than 0.1 percent of clinical psychologists are active in R&D). These data are from the Survey of Doctorate Recipients.

[13] In 1987, 16.1 percent of all employed clinical psychologists had earned their Ph.D.s in nonclinical psychology, and another 5 percent came from other fields. The reverse movement, from clinical to non-clinical psychology, was almost identical--16 percent, according to the Survey of Doctorate Recipients.

**Other Behavioral Sciences**

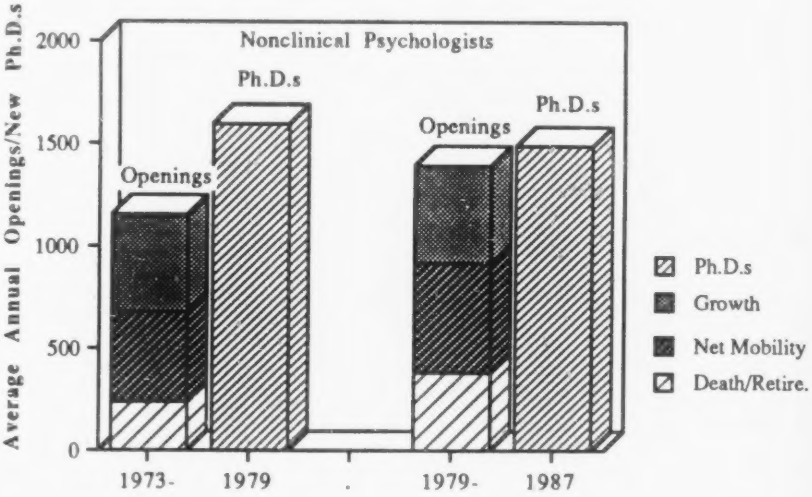
Employment in these fields increased at an annual rate of 4.8 percent for the 1973-1987 period (Figure 2-12). However, the growth rate for the 1983-1987 period slowed to 0.3 percent annually, and academic employment actually declined during the period. Academic employment of other behavioral scientists dominates their labor market: in 1987 almost 85 percent of academic employment was in colleges and universities, with the remaining 15 percent scattered across other employment categories. In 1987, total employment in other behavioral sciences was 12,735 (excluding 192 postdoctorates).

Other behavioral scientists engaged primarily in R&D averaged about 9 percent



SOURCE: Appendix Table A-3.

**Figure 2-10.** Average annual Ph.D. employment growth for R&D and total nonclinical psychologists, 1973-1987.



SOURCE: Appendix Table A-9.

**Figure 2-11.** Average annual job openings and new Ph.D.s in nonclinical psychology, 1973-1979 and 1979-1987.

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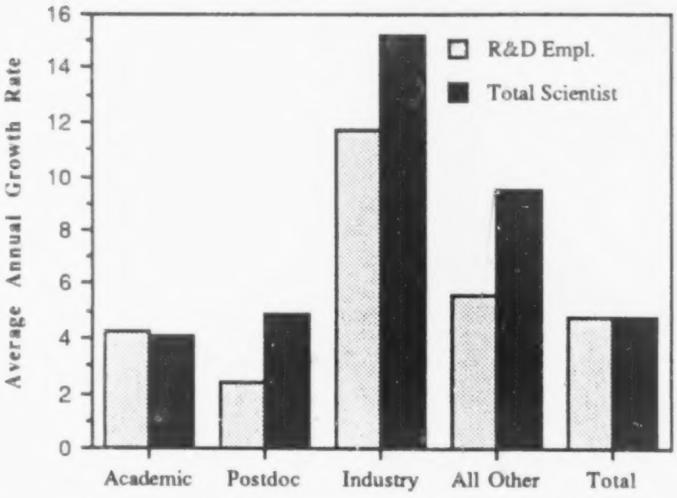
[14] For a more detailed discussion of the model used to estimate scientist attrition, see Joe G. Baker, "Biomedical/Behavioral Cohort Model: A Technical Paper," in Volume III of this report.

of total employment for the entire 1973-1987 period. Approximately 15 percent of those academically employed indicated that their primary work activity was in R&D. Postdoctoral appointments of other behavioral scientists comprised only 1.4 percent of the total work force in 1987.

In recent years, the majority of job openings for other behavioral scientists have resulted from attrition. Death and retirement (130 average annual openings) and negative net mobility (250 average annual openings) resulted in approximately 380 job openings annually during the 1973-1978 period; new growth required almost 780 scientists annually. In the 1983-1987 period, death and retirement (280 openings) and net mobility (370 openings) both exceeded annual growth positions (approximately 220 new Ph.D.s).



SOURCE: Appendix Table A-4.

**Figure 2-12.** Average annual growth in Ph.D. employment of other behavioral scientists by total and R&D, 1973-1987.

Degree production in other behavioral sciences fell steadily, from 1,307 Ph.D.s in 1976 to 882 in 1987, mirroring the decline in annual openings. The number of job openings per new other behavioral sciences Ph.D. had not changed substantially during the 1973-1987 period, ranging from 0.85 to 0.95 openings per each new Ph.D. Scientists who hold Ph.D.s in other behavioral science fields have also sought employment in other fields as a result of this soft market: in 1987 only about half of all scientists with Ph.D.s in other behavioral science fields were working as other behavioral scientists, compared with 71.9 percent in 1972.

## RECENT TRENDS IN THE LABOR MARKET FOR PHYSICIAN/SCIENTISTS

There is no precise tally of physician/scientists currently active in biomedical research, but indirect indicators point to a predominance of activities other than research. An example is a 1983 survey of full-time faculty within the departments of medicine at U.S. medical schools approved by the Liaison Committee on Medical Education (LCME).[15] Faculty in departments of medicine are traditionally viewed as being more involved in research activities than faculty from other clinical departments. The data from this survey can be used as an approximation of the upper limits of research effort for all full-time faculty. The survey found that 50 percent of the full-time faculty physicians spent less than 25 percent of their time conducting research; only 20 percent spent more than half of their time in research endeavors. This suggests that the expanding pool of full-time clinical faculty in medical schools (Figure 2-13) is a response to increasing patient care activities by clinical departments and does not reflect an increasing supply of

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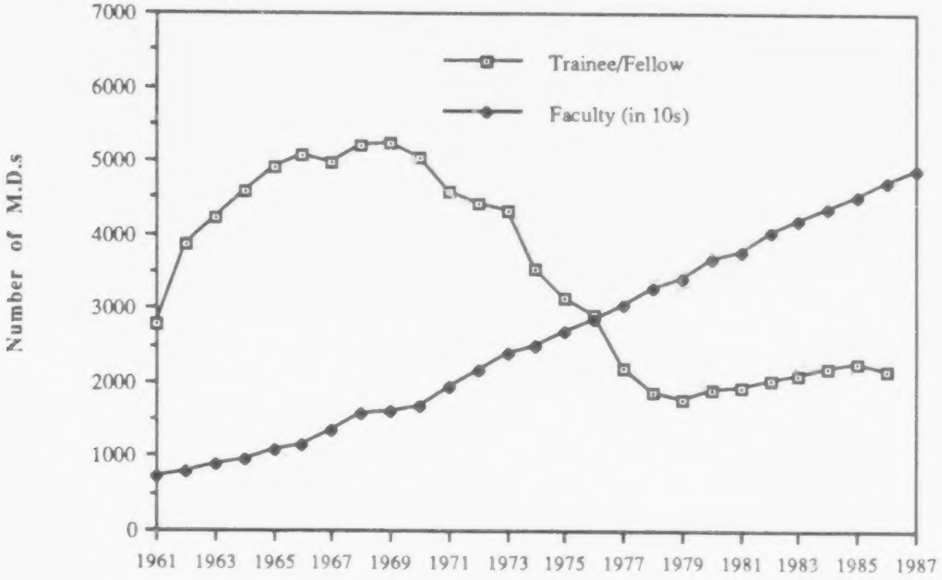
[15] H. N. Beaty, et al., "Research Activities of Faculty in Academic Departments of Medicine," *Annals of Internal Medicine*, vol. 104, 1986, pp. 90-97.



SOURCE: Appendix Table A-11.

**Figure 2-13.** Trends in M.D. postprofessional training and medical school faculty, 1961-1987; faculty in tens (e.g., 1976 = 28,603 faculty members and 2,918 trainees/fellows).

physician/scientists. Extrapolating from this survey, it can be estimated that, at most, only 20-30 percent of the full-time faculty in all clinical departments are actively engaged in biomedical research.

Several earlier studies also document the declining numbers of physicians entering careers in scientific investigation.[16] As a case in point, the number of physicians in research training programs sponsored by NIH decreased, from approximately 4,200 in 1969 to 1,910 in 1977 and has not increased significantly since then (see Figure 2-13).[17] This decline is explained, in part, by changes in program policy--much of the support in the 1960s and early 1970s was for training in medical subspecialities and required no research focus. Regardless, the number of physician trainees has not kept pace with growth in the physician population.

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[16] See, for example, S. O. Thier, et al., "Proposals Addressing the Decline in the Training of Physician Investigators: Report of the Ad Hoc Committee of the AAMC," *Clinical Research*, 1980, pp. 85-93; J. B. Wyngaarden, "The Clinical Investigator as an Endangered Species," *New England Journal of Medicine*, vol. 301, 1979, pp. 1,254-1,259; and G. F. DiBona, "Whence Cometh Tomorrow's Clinical Investigators?", *Clinical Research*, vol. 27, 1979, pp. 253-256.

[17] G. M. Carter, A. Robyn, and A. M. Singer, "The Supply of Physician Researchers and Support for Research Training: Part I of an Evaluation of the Hartford Fellowship Program," report N-2003-HF, (Santa Monica, CA: The Rand Corporation, 1983), pp. 46-47.

Data for NIH grant awards provide another indicator of declining research activity by full-time faculty with the M.D. degree versus those with a Ph.D. degree.[18] Of 11,683 grants in 1970, 36.7 percent (4,289) were awarded to M.D. principal investigators, 51.3 percent (5,993) to Ph.D.s, 5.9 percent (693) to M.D./Ph.D.s, and 6.1 percent (708) unknown. By 1987, when 24,384 grants were awarded, 26.2 percent (6,393) went to M.D.s, 63.9 percent (15,589) to Ph.D.s, 3.7 percent (902) to M.D./Ph.D.s, and 6.1 percent (1,498) unknown. Although the number of grants to M.D.s increased, their share of total growth fell.

## COMPOSITION OF THE LABOR FORCE

### Race and Sex

Over the past decade, those concerned with the scientific work force have researched and written extensively about the underrepresentation of women and minorities in that sector.[19] This concern is motivated by reasons of both equity and strategy. But while the composition of the scientific work force reflects increasing numbers of individuals other than the traditional pool of white males, the participation of women and minorities in science is still far lower than their participation in the overall labor force . For instance, nearly 45 percent of the 1987 U.S. labor force was made up of women, but only about 22 and 34 percent of biomedical and behavioral scientists were female.[20]

The distribution of minorities in science differs even more sharply from that in the larger labor force: blacks and all other minorities except Asians are underrepresented by factors of 6 or 7. In addition, while the percentage of women in the scientific work force is growing at a relatively rapid pace, the growth in the number of racial and ethnic minority scientists is painfully slow.

An important trend in the general labor force also holds for biomedical/behavioral doctorate recipients: a much more rapid growth in the rate of entry for women than for men. Although the number of awards to minority males in biomedical science grew only slightly between the time period 1978-1982 and the time period 1983-1987 (3.61 percent), growth in the number of awards to minority women (27.5 percent) resembled that of white women. The trends were similar in the behavioral sciences, where female participation is traditionally higher; by the mid-1980s, over half of all behavioral Ph.D.s were being awarded to women. Comparable data are not available for physician/scientists.

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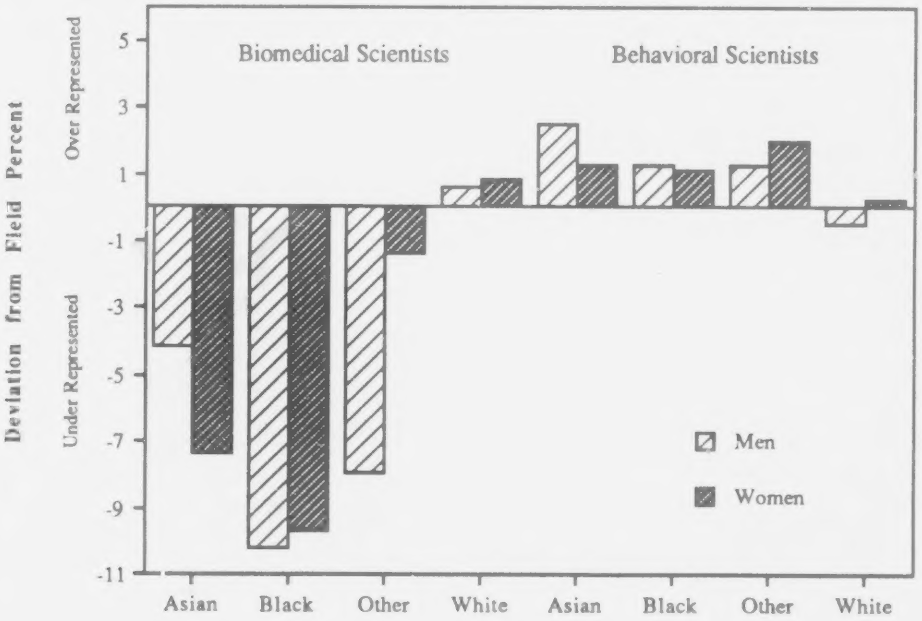
[18] B. Healy, "Innovators for the 21st Century: Will We Face a Crisis in Biomedical-Research Brainpower?," *New England Journal of Medicine*, vol. 319, 1988, pp. 1,059-1,064.

[19] See, for instance, The White House Task Force on Women, Minorities and the Handicapped in Science and Technology, *Changing America: The New Face of Science and Engineering*, Washington, D.C.: September 1988; National Science Foundation, *Women and Minorities in Science and Engineering*, Washington, D.C.: U.S. Government Printing Office (a biennial publication beginning in 1982); National Research Council, *Women: Their Underrepresentation and Career Differentials in Science and Engineering*, Washington, D.C.: National Academy Press, 1987; National Research Council, *Minorities: Their Underrepresentation and Career Differentials in Science and Engineering*, Washington, D.C.: National Academy Press, 1987; and Government-University-Industry Research Roundtable, *Nurturing Science and Engineering Talent*, Washington, D.C.: National Academy Press, 1987.

[20] Data are from National Research Council, Survey of Doctorate Recipients, 1987; and Council of Economic Advisors, *Economic Report of the President 1989*. Washington, D.C.: U.S. Government Printing Office, 1989.

To determine whether there is an association between race or sex and the careers of biomedical and behavioral Ph.D.s, the committee examined predoctoral support, postdoctoral plans, and a career outcome of those in the doctoral labor force in the biomedical and behavioral sciences.[21] Figure 2-14 indicates that the distribution of NIH predoctoral support to graduate students is not independent of race and sex in some cases. Both this figure and the two that follow show percentage point deviations of the race/sex groups from their respective field percentages. For instance, 23.3 percent of all biomedical degree recipients in the period 1983-1987 reported NIH as the primary source of support in graduate school. The comparable figure for black women in that group was 13.6 percent or 9.7 percentage points below the field percentage; in other words, black women were 9.7



SOURCE: Appendix Table A-12.

**Figure 2-14.** Under- and over-representation of race/sex groups in NIH predoctoral support for biomedical (field percent = 23.3) and behavioral (field percent = 2.9) doctoral recipients, 1983-1987.

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[21] The first group contains so few minority members in any given year that the committee, using the National Research Council's Survey of Earned Doctorates (SED), aggregated cohorts of doctorate recipients over two five-year periods to investigate both differentiation and change. For the same reason, it would have been desirable to aggregate across cohorts of the Survey of Doctorate Recipients (SDR), used for compilation of the second group, but the longitudinal nature of the SDR would have involved multiple counting of individuals. Hence, the two single years, 1977 and 1987, were selected for analysis of these populations.

percent underrepresented. The reasons for this are not known, however, and the numbers are small. Figure 2-14 shows that minority groups are uniformly underrepresented among basic biomedical doctorate recipients reporting NIH as their primary source of predoctoral support. In the behavioral fields, the situation is reversed, but the deviations are trivial.

The underrepresentation of minority graduate students with NIH support is surprising, given major efforts to target minorities within NIH/ADAMHA. In addition to the MARC program, noted in the Executive Summary, NIH provides summer research apprenticeships for minority high school students, research grant supplements for projects that employ minority students or faculty, and strong directives to grant applicants and internal staff concerning procedures for recruiting minorities.[22] Despite these efforts, the growth of the minority doctoral population in these fields has been slow. Possible explanations for the inconsistency between the size of the NIH/ADAMHA minority programs and low levels of actual minority student support include the following:

- The major mechanism for predoctoral support within NIH/ADAMHA is the T32 institutional training program. The selection of individual applicants in these programs is left up to the institutions. NIH/ADAMHA requires schools receiving T32 grants to have a minority recruitment program; it is not known how effective the individual institutions are in recruiting minorities nor how underrepresented minorities may be in the institutions.

- The NIH/ADAMHA minority programs may simply be ineffective. For example, if minorities have higher attrition rates and longer time to degree than other students, fewer Ph.D.s are produced per given level of predoctoral support. Thus NIH/ADAMHA support for predoctoral minority students may be high, but relatively few of these students may receive Ph.D.s.

- The inconsistency between NIH/ADAMHA minority programs and actual levels of minority student support may be due to data bias. Students responding to the Survey of Earned Doctorates may not be sure what their source of support was during graduate school.[23]

The causes of the low levels of minority student support and Ph.D. awards are clearly a cause for concern. The committee recommends program evaluations and pipeline studies as a start to sort out the causes of these troubling statistics (see recommendations in chapter 5).

To learn about postdoctoral plans, the committee relied on the SED, which asks whether respondents have definite plans for future study or employment at the time of completing the survey form, usually when the dissertation is accepted; those who answer negatively are displaying ambiguity about their careers. Figure 2-15 displays the levels of such uncertainty and any possible differentials by field, race, and sex; every measured effect operates in ways that are highly significant, both statistically and substantively. For example, about 9 percent fewer behavioral than biomedical majors report definite plans. A

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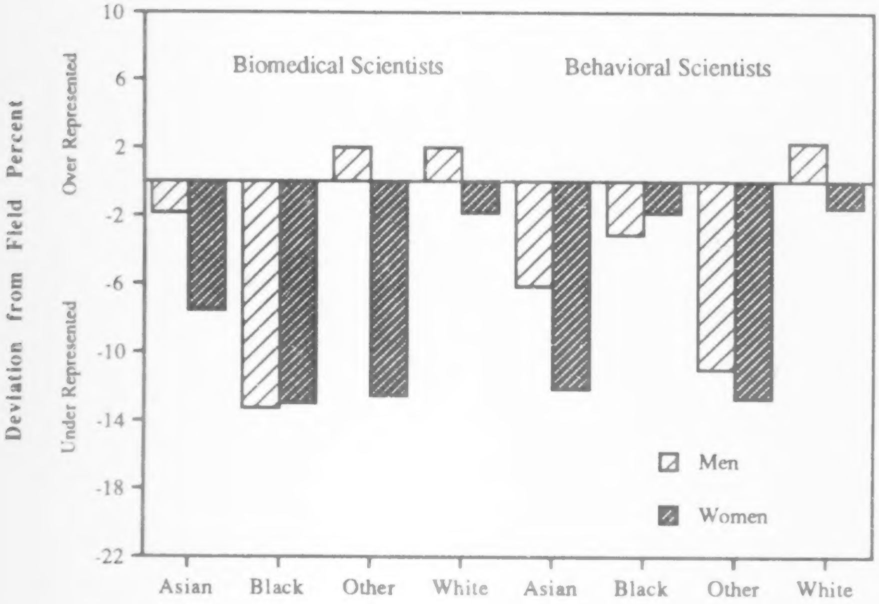
[22] For details, see *NIH Guide for Grants and Contracts, Special Issue: Initiatives for Underrepresented Minorities in Biomedical Research*, vol. 18, no. 14, April 21, 1989.

[23] There are indications that minorities in the life sciences are receiving federal support from all sources at rates comparable to other groups. Those indicating primary support from any federal source were 23.8 percent overall, 20.0 percent for American Indians, 43.7 percent for Asians, 31.3 percent for blacks, 29.5 percent for Hispanics, and 26.9 percent for whites. See National Research Council, *Summary Report 1988: Doctorate Recipients From United States Universities*, Washington, D.C.: National Academy Press, 1989, Table L.



SOURCE: Appendix Table A-13.

**Figure 2-15.** Under- and over-representation of race/sex groups in reporting definite postdoctoral plans of biomedical (field percent = 88.5) and behavioral (field percent = 79.2) doctoral recipients, 1983-1987.

larger fraction of whites report definite plans than do minorities; and in all categories other than black, fewer women than men report definite career plans.

The committee believes that the data in Figures 2-14 and 2-15 are indicative of inadequate mentoring at the predoctoral level: role models for women and minorities are too few in number, and contacts with faculty may be too sparse to provide needed guidance in seeking NIH support in graduate school and in career planning. These factors are very likely compounded with others, such as inadequate precollege preparation. Whatever the specific mix of causes, the committee interprets the data as suggesting a clear need for future research and appropriate action.

These patterns in degree awards are having predictable time-lagged effects on the composition of the biomedical and behavioral labor force. The data in Table 2-1 reflect an average annual growth rate of about 4.7 percent in the size of the total labor force between 1977 and 1987. During that time period, the percentage of women in both doctoral fields grew substantially, to more than 20 percent of the biomedical work force and more than one-third of the behavioral scientists. The average annual growth in the numbers of white females were 7.7 and 8.3 percent, respectively; these rates of increase were shared by nonwhite women and, to a lesser extent, by minority males. The only groups growing at less than these rates were white males, whose numbers increased by only 3.6 and 2.9 percent in the biomedical and behavioral fields, respectively.

TABLE 2-1: Doctoral Biomedical and Behavioral Labor Force, by Sex and Race, 1977 and 1987

| | | Biomedical | | Behavioral | |
|---|---|---|---|---|---|
| | | 1977 | 1987 | 1977 | 1987 |
| MEN | Asian | 4.83 | 6.95 | 1.04 | 1.20 |
| | Black | 1.00 | 1.01 | 0.78 | 1.14 |
| | Other | 1.06 | 1.21 | 0.82 | 1.32 |
| | White | 77.27 | 69.25 | 73.39 | 61.91 |
| WOMEN | Asian | 1.28 | 2.04 | 0.35 | 0.65 |
| | Black | 0.25 | 0.40 | 0.54 | 1.06 |
| | Other | 0.15 | 0.35 | 0.22 | 0.69 |
| | White | 14.16 | 18.78 | 22.86 | 32.03 |
| | | ---- | ---- | ---- | ---- |
| | Total (a) | 100.00 | 100.00 | 100.00 | 100.00 |
| | Number | 53,037 | 84,045 | 41,238 | 65,170 |

a/ Excludes those who are retired or not reporting.

SOURCE: NRC, Survey of Doctorate Recipients.

Women nevertheless appear to be underrepresented in a basic outcome of receiving a doctorate in biomedical or behavioral science: full-time employment as a scientist.[24] In 1987 more than 90 percent of the biomedical and 85 percent of the behavioral scientists were so employed; of the remainder, about half were employed part-time (mostly in science); 38 percent were unemployed; and 23.1 percent were unemployed but not seeking a position. Figure 2-16 dramatizes the disproportionately low percentage of eligible women employed full-time in scientific work: 18.4 percent of all women biomedical Ph.D.s in 1987 were not doing full-time science, but this is down from nearly a quarter in 1977. Race, however, was an insignificant factor in determining participation rates in full-time biomedical science. The situation is similar for the behavioral sciences.

These data have clear, important implications for science policymakers. If the fraction of biomedical and behavioral science Ph.D.s not doing science full-time remains in excess of 15 percent, and if the fraction of degrees awarded to women continues to increase, the projected personnel shortage will be exacerbated (see Chapter 3).

## Citizenship

Although U.S. science has long relied on the contributions of immigrants, the increasing number of foreign graduate students requires that the role of foreign students and immigration be included in any assessment of the adequacy of the supply of biomedical and behavioral scientists in the United States.

In 1988 foreign students earned 18.1 percent of the doctorates in biological sciences awarded by U.S. institutions, up from 11.8 percent in 1980. In the behavioral sciences the proportion earned by foreign students was less: 7.3 percent in 1988, up from 6.1 percent in 1980. Foreign students who are permanent residents at the time they earn their doctorates

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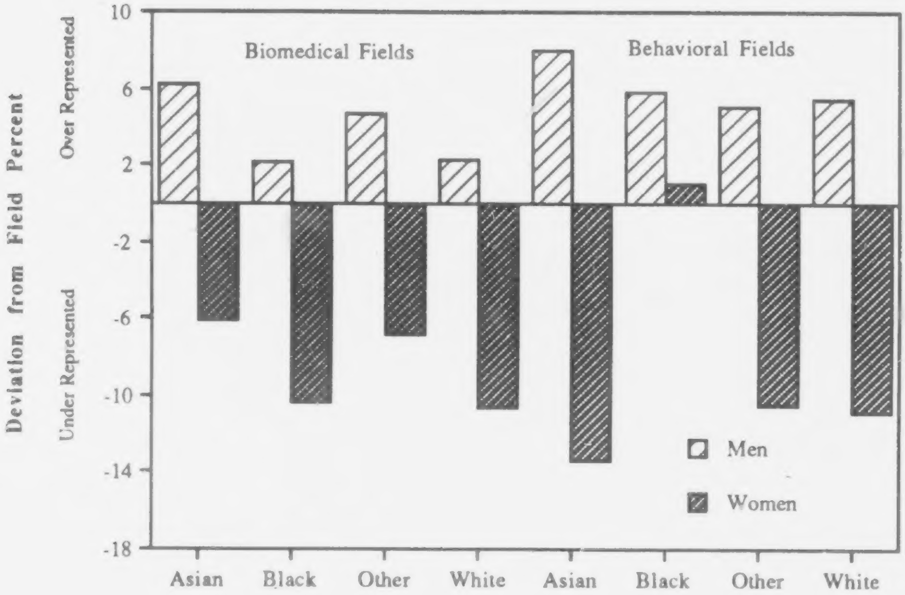
[24] Another normal outcome, in the biomedical sciences at least, is that of postdoctoral study. Those reporting current postdoctoral study are eliminated from the denominators of percentages reported in Figure 2-16 and the corresponding appendix table.



SOURCE: Appendix Table A-15.

**Figure 2-16.** Under- and over-representation of race/sex groups in full-time employment in the S&E labor force of biomedical (field percent = 92.3) and behavioral (field percent = 85.6) scientists, 1987.

behave very much like U.S. citizens. For example, they virtually all stay in the United States to work.[25] During the 1980s, however, about 74 percent of the foreign degree recipients in the biological sciences and about 65 percent in the behavioral sciences were, at graduation, temporary residents who behave very differently from U.S. citizens: only about one-fourth of the temporary residents were still in the United States working or doing postdoctoral study 1-2 years after graduation. Furthermore, evidence shows that foreign nationals who enter the U.S. work force tend to emigrate from the United States at a faster rate than persons who were U.S. citizens at the time of receiving the doctorate. In the life sciences and the social/behavioral sciences, consequently, foreign recipients of U.S. doctorates comprise a comparatively small part of the increases in the doctoral work force--approximately 6 and 4 percent, respectively--in contrast to engineering, where they contribute 37 percent of the growth.[26]

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[25] If we consider all foreign degree recipients, the proportion staying here to work goes up to about 40 percent. See Michael G. Finn, *Foreign National Scientists and Engineers in the U.S. Labor Force, 1972-1982*, Oak Ridge, TN: Oak Ridge Associated Universities, 1985.

[26] Michael G. Finn and Sheldon B. Clark, *Estimating Emigration of the Foreign-Born Scientists and Engineers in the United States*, Oak Ridge, TN: Oak Ridge Associated Universities, 1988.

# CHAPTER 3

# THE FUTURE LABOR MARKET FOR BIOMEDICAL AND BEHAVIORAL RESEARCH PERSONNEL

## OVERVIEW

Labor market projections for this report were expanded to include demand from industry, government, and other nonacademic sources. Labor demand projections reflect increased attrition due to the aging of the work force. The model has also been refined in its reflection of the various segments of the market for biomedical and behavioral scientists. Finally, the committee attempted to extend its projections to the year 2000.

For biomedical scientists, the projected current Ph.D. production is inadequate to meet growing demand. Employment growth is driven by industry, which may become the largest employer by 1995. Jobs in R&D increase more rapidly than in non-R&D. Because of demand growth and higher attrition, Ph.D. production must increase.

For behavioral scientists, the labor market should remain in approximate balance. Growing demand for clinical psychologists may draw behavioral Ph.D.s out of R&D. The market for nonclinical psychologists is projected to be in approximate balance in the 1990s, and the model indicates a stable market for other behavioral scientists--anthropologists, sociologists, audiologists, and speech pathologists.

The labor market for physician/scientists is more difficult to project. Recent studies indicate that the demand for clinical investigators has been overstated in the past. However, a number of factors suggest that the demand for well trained physician/scientists will increase in the future.

Extended projections to the year 2000 reflect similar trends. Demand for biomedical scientists could be twice the current level of biomedical Ph.D. production. The market for behavioral scientists is in better balance with supply unless growth is higher than expected. The demand for physician/scientists could grow substantially, particularly if significant numbers of M.D.s are drawn into basic research in the biomedical sciences.

## PRIOR COMMITTEE PROJECTIONS AND CURRENT METHODOLOGY

The legislation mandating this study requires the committee to assess "the nation's overall need for biomedical and behavioral research personnel."[1] Past committees have defined this "need" in labor market terms--that is, how many biomedical and behavioral researchers will be "needed" in the future to fill academic demand?

Job openings were determined by growth in the number of academic positions and faculty attrition. These projections were developed for the near term; the 1985 committee report included projections to 1990. This report expands the earlier analysis in several ways:

1. In almost every biomedical and behavioral field, the major source of historical and projected employment growth is in nonacademic sectors,

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[1] Section 489 of P.L. 99-158.

primarily private industry. This report expands the labor market analysis to include industry, government, hospital, and other nonacademic sources of labor demand for biomedical and behavioral scientists.[2]

2. This analysis develops separate projections for the labor market in general and for that subsection of the labor market associated with scientists whose primary work activity is R&D or the management of R&D.

3. Given concern over the graying of the work force, the current analysis includes a demographic/economic model for estimating scientist attrition due to death, retirement, and net occupational movement. Attrition in this model is a function of the age and experience structure of the scientist work force.

4. The analysis brings labor supply into the labor market assessment. This was not done in earlier reports.

5. Given that the median time to complete a biomedical Ph.D. has grown from seven years in the late 1970s to eight years in 1987, the 1997 biomedical scientist labor market will be influenced by student decisions and NRSA policy in 1989. In the behavioral sciences, median time to Ph.D. has increased from approximately 8.5 years to 10.5 years during the same period. These time lags argue for a longer horizon of analysis. Consequently, the current study projects labor market variables to the year 2000.[3]

## THE MODEL

Figure 3-1 is a schematic drawing of the labor market assessment model used in this report.[4] The stock of scientists in time period *t* is characterized by biological age (years since birth) and career age (years since degree). Historical data provide estimates of the deaths and retirements by biological age; these scientists are removed from the stock. Those who do not retire or die can also leave the field for other employment; this too is

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[2] Although the NRSA program is concerned only with research personnel, it is necessary to take account of the total demand for biomedical and behavioral scientists to ensure that an adequate supply is available. Rapid employment growth in the industrial sector could create hiring difficulties in the academic sector even if academic sector employment is stable or declining.

[3] Despite the more secular nature of the model, it is unlikely that shifting demographics will substantially affect the analysis. The National Center for Education Statistics' (NCES) demographic model projections indicate that M.D.s and first-professional degrees will "increase slightly or remain stable" through 1998. NCES also projects college enrollments to decline from 12.56 million in 1988 to 12.17 million in 1998 (midcase). These points indicate that demographics will not have major influences on supply of Ph.D.s or demand for faculty during the projection period. See NCES, *Projection of Education Statistics to 1997-1998*, Washington, D.C.: U.S. Government Printing Office, 1988.

[4] For a more complete discussion of the labor market assessment model, see Joe G. Baker, "Biomedical/Behavioral Cohort Model: A Technical Paper," in Volume III of this report.

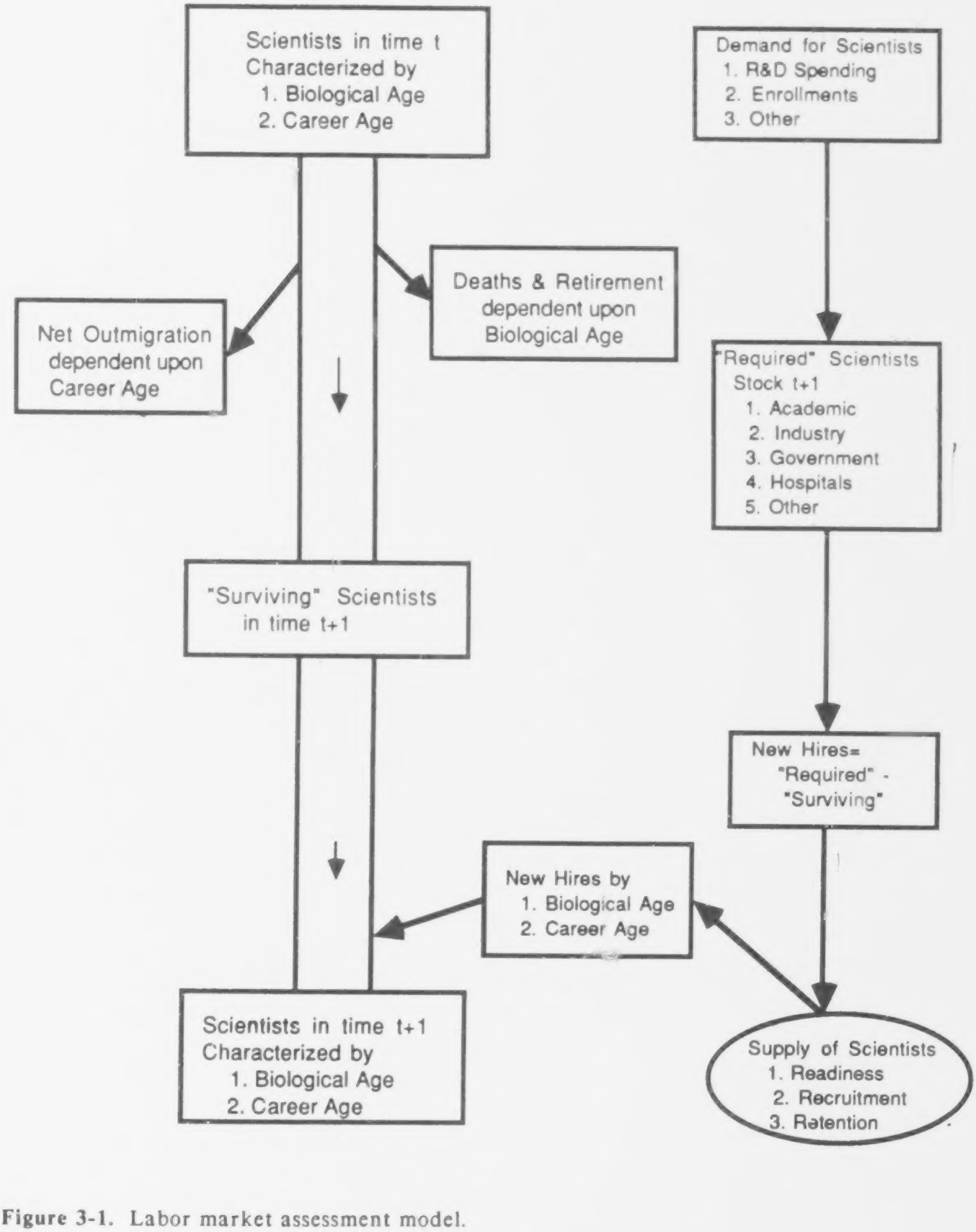
Scientists in time t
Characterized by
1. Biological Age
2. Career Age
Demand for Scientists
1. R&D Spending
2. Enrollments
3. Other
Deaths & Retirement dependent upon Biological Age
Net Outmigration dependent upon Career Age
"Required" Scientists Stock t+1
1. Academic
2. Industry
3. Government
4. Hospitals
5. Other
"Surviving" Scientists in time t+1
New Hires= "Required" - "Surviving"
New Hires by
1. Biological Age
2. Career Age
Scientists in time t+1
Characterized by
1. Biological Age
2. Career Age
Supply of Scientists
1. Readiness
2. Recruitment
3. Retention

**Figure 3-1.** Labor market assessment model.

assumed to be a function of career age.[5] Estimates of migration presented here are net (outmigration less inmigration from other fields) and are estimated from historical data. The surviving scientist stock is available for employment in period *t+1*.

The required scientist stock in period *t+1* is estimated from submodels that link demand for scientists to the demand for the goods and services that scientists produce (e.g., conducting R&D or training graduate students). The submodels were constructed from demand equations that were estimated from historical data. For example, non-R&D biomedical industrial employment was estimated to be a function of real constant dollar output of the pharmaceutical industry; R&D biomedical industrial employment was estimated to be a function of real constant dollar, private sector, health-related R&D spending. These demand submodels vary by discipline (biomedical, behavioral, clinical), sector (academic, industrial, government, etc.), and activity (R&D, non-R&D).

The difference between the surviving scientist stock and the required scientist stock in period *t+1* represents the number of job openings that must be filled by new entrants. These job openings are compared to supply to compute "vacancy ratios," (i.e., the number of job openings per new Ph.D.). Increases or decreases in future vacancy ratios from historical ratios give one a sense of changes in the projected demand/supply balance in the scientist labor market. This same basic analysis is replicated for the R&D subsector by comparing R&D job openings to postdoctoral "graduates."

Obviously, the number of job openings is dependent upon a wide range of other variables, including health R&D expenditures, general economic growth, wage rates, and other labor market factors. Likewise, decisions to enroll in graduate school are based in part on current student support, starting salaries, expected future earnings, earnings available in alternative careers, and other factors. In the simplified approach used here, however, we have implicitly assumed that these excluded variables are constant; we are primarily concerned with major shifts in the demand and supply of scientists through time. While the resulting analysis takes little account of the responses of institutions and individuals to changing labor market conditions, the projections contained in this chapter do serve to highlight the consequences of current trends and suggest courses of corrective action.[6] Where possible, we do discuss potential labor market adjustments to changing conditions.

## THE FUTURE LABOR MARKET FOR BIOMEDICAL SCIENTISTS

The demand for biomedical scientists is derived from demand for the goods and services they produce, primarily biomedical research and instruction. In order to estimate the future need for biomedical scientists, we must estimate the level of demand for these goods and services, e.g., the level of health-related R&D to be conducted and the levels of undergraduate and graduate enrollment. Massive new public health efforts in areas such as AIDS research could increase the demand for health research personnel significantly.

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[5] This is based upon the assumption that there is a "career pattern" of outmobility based upon years since Ph.D. (e.g., the probability that one would leave his/her degree field for other employment is small immediately after receipt of the degree; but in later years scientists may move into management and administration). The reader is referred to the current labor market section for estimates of these outmigration rates.

[6] An econometric approach to projecting the biomedical scientist labor market that included prices and feedback mechanisms produced results consistent with this chapter. See Joe G. Baker, "The Ph.D. Supply Crisis: A Look at the Biomedical Sciences," paper given at the Western Economics Association Meetings, Lake Tahoe, Nevada, July 21, 1989.

Private sector research, especially in the emerging biotechnology industry, has the potential to command an increasing portion of limited biomedical scientific resources. Demand for teaching faculty is dependent upon the enrollment levels in graduate programs as well as on university R&D. As the biomedical scientist cadre matures, attrition from death and retirement will increase the demand for replacement in these areas.

**Growth in Employment**

In order to provide projections of future demand for biomedical scientists, the committee developed the following scenarios, which are summarized in Table 3-1:

1. *Low Case*: The low-case scenario corresponds to a conservative retrenchment from current trends: cuts are imposed on growth rates of federal health R&D, and the private sector retreats from current growth levels. In this scenario, both federal and private health-related R&D slow to approximately half their current rates of growth. Graduate and undergraduate enrollment in biomedical sciences decline by 1 percent annually.

2. *Mid Case*: The mid-case scenario is largely "status quo" with regards to both federal and private health- related R&D funding. Enrollments are assumed to be stable at 1987 levels.

3. *High Case*: The high-case scenario is based on large increases in health-related R&D funding in such areas as AIDS and alcohol and drug addiction. Private sector efforts in biotechnology and other areas exceed historical levels. Enrollments are assumed to grow by 1 percent annually.

TABLE 3-1. Projection Model Assumptions, Biomedical Sciences

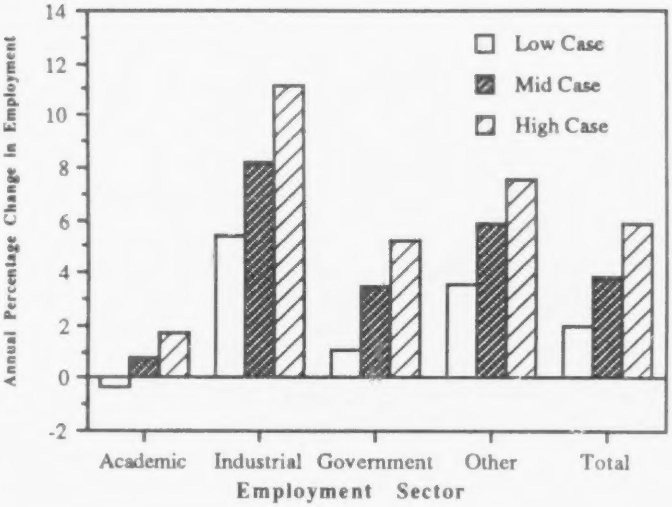
| | Historical Annual Growth Rate | | | Assumptions for Future Annual Growth Rate | | |
|---|---|---|---|---|---|---|
| Variable | 10 Year | 5 Year | 1 Year | Low | Mid | High |
| Real Health R&D Expenditures | | | | | | |
| Federal | 2.7% | 5.4% | 7.3% | 1.5% | 2.7% | 4.0% |
| Private | 9.3% | 10.3% | 9.6% | 5.0% | 9.0% | 13.0% |
| Other | [illegible].2% | 8.8% | -1.1% | 2.0% | 3.0% | 4.0% |
| Enrollment in Universities | -0.3% | -0.2% | -0.3% | -1.0% | 0.0% | 1.0% |
| New Ph.D.s | 1.4% | 0.0% | 2.7% | -1.0% | 0.0% | 1.0% |

SOURCE: Volume II, Tables B1, B3, and B8. Projection assumptions developed by the committee.

Projections of the required stock of scientists (Figure 3-1) were developed using these assumptions in the labor demand submodels. Figure 3-2 details the results of these projections. Regardless of the scenario chosen, the same basic trend is evident: industrial employment of biomedical scientists dominates growth in the future labor market, and in all but the low case it becomes the largest employment sector by the year 1995. Historical growth in biomedical employment averaged 4.8 percent annually for the 1973-1987 period; the projected growth rates for the low, mid, and high cases are 1.8 percent, 3.6 percent, and 5.2 percent, respectively. Biomedical scientists engaged primarily in R&D or the management of R&D will grow faster than the biomedical work force in general. This is because private industry, in which a high percent of biomedical scientists are engaged in R&D, is projected to grow faster than the other employment sectors.

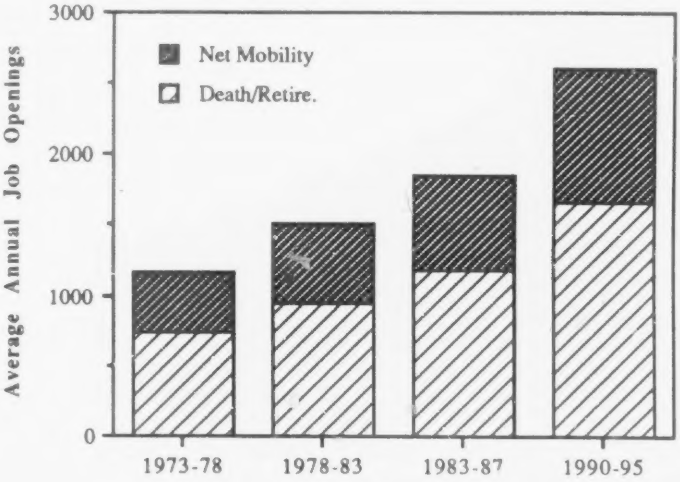
**Attrition**

Job openings are also created by death, retirement, and outmobility. Given the graying of the scientific work force, these openings are expected to increase in the future.[7] Figure 3-3 portrays the estimated number of openings from death, retirement, and net outmobility for historical and projected periods (mid-case scenario). Openings due to death and retirement are projected to increase from approximately 1,200 per year in the latter 1980s to 1,650 per year for the 1987-1995 period. Net worker mobility, which created approximately 650 job openings annually in the 1980s, is projected to increase to 950 per year for the 1987-1995 period. For the 1987-1995 period, therefore, approximately 2,600 new scientists will be required annually just to maintain *current* employment levels. This



SOURCE: Appendix Table A-18.

**Figure 3-2.** Projected annual growth rates for biomedical scientists, 1987-1995.



SOURCE: Appendix Table A-8.

**Figure 3-3.** Historical and projected biomedical scientist attrition, 1973-1995.

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[7] In 1987, approximately 10,800 employed biomedical scientists were aged 55 or older. Under the mid-case scenario, this will grow to approximately 15,500 in 1995. See Joe G. Baker, "Biomedical/Behavioral Cohort Model: A Technical Paper," in Volume III of this report.

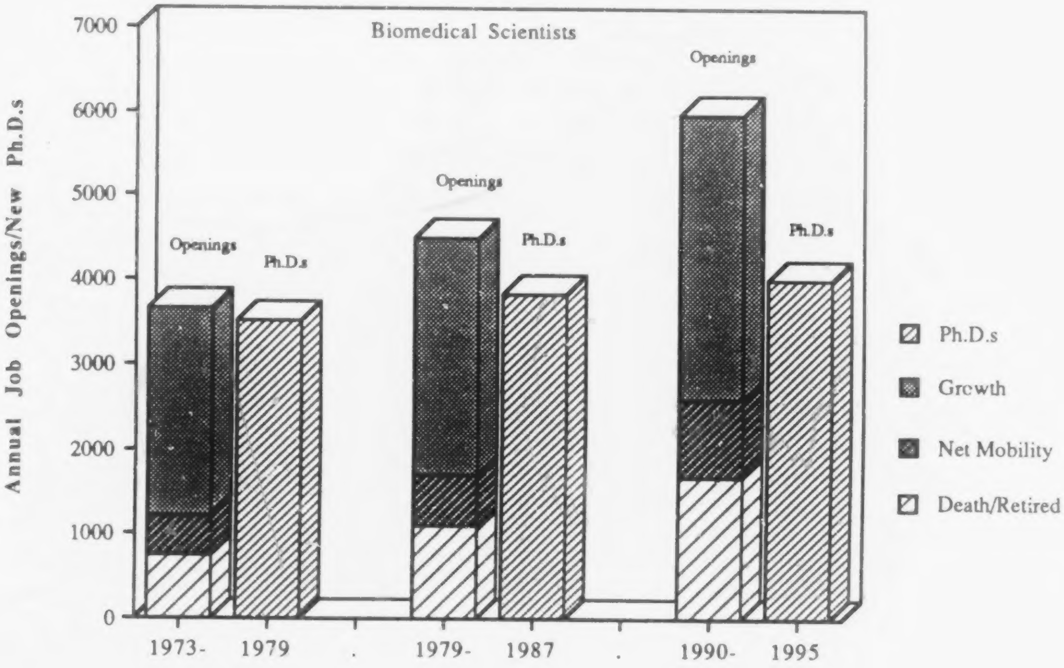
figure will rise to approximately 3,400 by the year 2000. Given that about 4,000 Ph.D.s are awarded currently, growth in employment can occur only if the number of Ph.D.s increases.

**Future Demand and Supply**

The sum of openings due to attrition and growth is the total number of "new hires" required annually (Figure 3-1). Figure 3-4 compares the projected labor demand (job openings) to labor supply (new biomedical Ph.D.s). It shows that the number of positions per new biomedical Ph.D. has grown during the 1980s over the 1970s. Assuming that degree production changes in proportion to enrollments (-1, 0, and 1 percent growth for the three scenarios), both the mid-case and high-case scenarios will produce even greater imbalances between job openings and new biomedical Ph.D.s.

In summary, the committee projects a future labor market for biomedical scientists that is characterized by increasing imbalance between demand and supply. Because death and retirement are expected to double in the next decade, and because most of the openings created by retirement will be in academe, this presages a time of unprecedented competition between academic institutions and the emerging biotechnology industry. This situation can be avoided by some combination of the following factors:

o *Decreased growth:* Current biomedical Ph.D. production could support future demand if future growth is in the neighborhood of 2 percent annually. However, this is a considerable decrease from the 4.8 percent historical growth rate in biomedical Ph.D. employment.



SOURCE: Appendix Table A-19.

**Figure 3-4.** Average annual biomedical job openings and new Ph.D.s, 1973-1995.

- *Increased production*: Biomedical Ph.D. production could support faster growth if the number of degrees increases from the current level of 4,000 per year to the 5,000-6,000 range. Given current trends in first-year graduate enrollments in biomedical sciences, however, there is likely to be no major increase in Ph.D. production until the mid-1990s.[8]

- *Decreasing graduate school attrition and time to degree*: The high rates of graduate student attrition and lengthy time to degree increase the sluggishness and decrease the productivity of graduate schools in the production of new scientists. Little is known about the causes of these problems; therefore it is difficult to offer solutions other than more research. If time to the doctorate and attrition could be reduced, however, the benefits would be more immediate than increasing enrollments.

- *Increased retention of women*: Female scientists have much higher dropout rates than men (see Chapter 2). If programs were developed to increase full-time science participation by females who hold Ph.D.s, effective labor supply would increase.

- *Recruitment of outside Ph.D.s*: Inmobility of Ph.D.s from other fields could increase. Recruiting new entrants from other fields is viable so long as there are people in other fields to draw on. However, most studies of the science and engineering labor market in the 1990s project a similar imbalance between new Ph.D.s and job openings in other fields. Therefore, it may become increasingly difficult to draw entrants from other fields. Also, these entrants may not be as productive as scientists with degrees in biomedical sciences, and there may be other costs associated with hiring them, such as training costs or increased supervision requirements. Very little is known about these tradeoffs, however.

- *Decreased attrition*: Patterns of outmobility and retirement could change; perhaps incentives could be developed to affect this behavior such as rewarding delayed retirement.

- *Recruitment of foreign Ph.D.s*: Foreign nationals with permanent visas could help meet U.S. science need.

## THE FUTURE LABOR MARKET FOR BEHAVIORAL SCIENTISTS

The behavioral sciences are made up of a group of disciplines that includes clinical psychology, nonclinical psychology, anthropology, sociology, and speech pathology (these latter three are grouped together as "other behavioral sciences"). Clinical psychologists are mainly involved in patient care; the behavioral science disciplines that are R&D-oriented are nonclinical psychology and other behavioral sciences.

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[8] If one assumes that biomedical Ph.D. output will change in parallel with lagged first-year biomedical graduate enrollment change, one can estimate Ph.D. labor supply through 1995 based upon current enrollment, although historically such a model yields a poor fit. Using this assumption does not substantially change the results, however: the lagged enrollment model shows Ph.D. output in the biomedical sciences increasing very slowly, from 4,000 in 1987 to only 4,100 in 1995. See Joe G. Baker, "The Ph.D. Supply Crisis: A Look at the Biomedical Sciences."

The future labor market for clinical psychologists is projected to be characterized by increasing imbalance of demand over supply. Given that most of this growth is practice-related, the direct consequences for behavioral science research personnel are slight. However, clinical practice will offer an attractive employment opportunity for behavioral scientists in general, and could be expected to draw scientists from R&D activities.[9]

### Nonclinical Psychology

Nonclinical psychologists make up approximately 30 percent of the behavioral scientist work force. Unlike clinical psychologists, their work consists largely of teaching and research. Over 80 percent of nonclinical psychologists work in private industry or academic settings; the remaining 20 percent are distributed among government, hospitals, and other employment sectors.

The key assumptions employed for projecting future levels of demand for nonclinical psychologists appear in Table 3-2 and are summarized here:

- o Graduate enrollment growth in the behavioral sciences is modest or negative under three scenarios: low case (-1.0 percent annually), mid case (0.0 percent), and high case (1.0 percent).

TABLE 3-2. Projection Model Assumptions, Behavioral Sciences

| | Historical Annual Growth Rate | | | Assumptions for Future Annual Growth Rate | | |
|---|---|---|---|---|---|---|
| Variable | 10 Year | 5 Year | 1 Year | Low | Mid | High |
| Graduate Enrollment in Universities | 1.1% | 0.2% | -0.3% | -1.0% | 0.0% | 1.0% |
| Industrial Employment of Nonclinical Psychologists | 6.6% | 3.7% | 3.2% | 2.0% | 3.0% | 4.0% |
| Nonacademic employment of Other Behavioral Scientists | | | | | | |
| R&D | 3.5% | -2.2% | 38.9% | 3.0% | 5.0% | 7.0% |
| NonR&D | 14.4% | 15.7% | -2.0% | 7.0% | 10.0% | 15.0% |
| New Ph.D.s | -0.7% | -1.1% | -1.8% | -1.0% | 0.0% | 1.0% |

SOURCE: Volume II, Tables C1, C10-1, and Table A-10 from Joe G. Baker, "Biomedical Cohort Model: A Technical Paper" in Volume III of this report. Projection assumptions developed by the committee.

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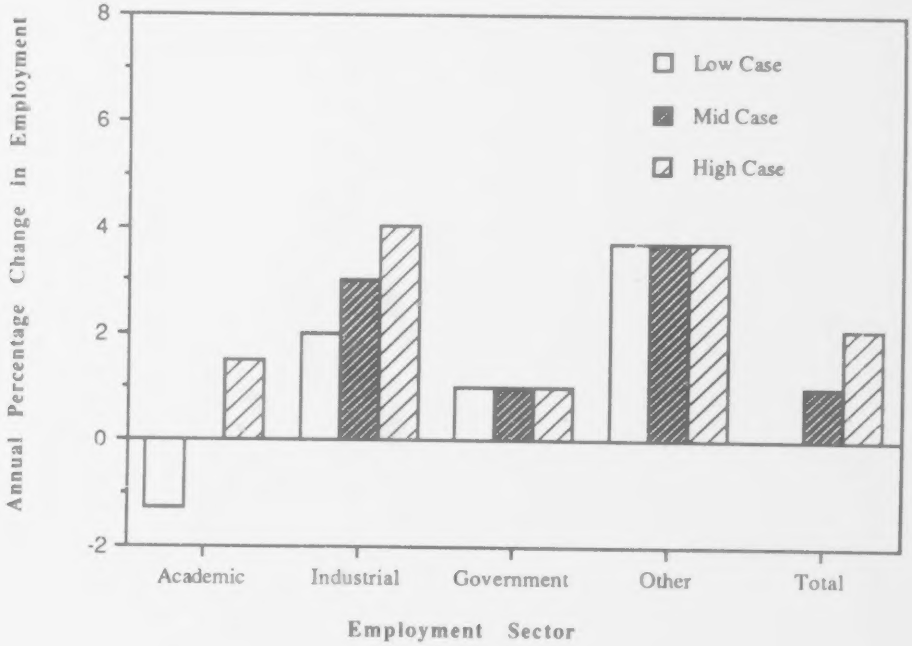
[9] In 1987 about 20 percent of employed clinical psychologists had degrees in other fields. However, future movement into the field may be slowed by changes in state certification requirements.

- Demand growth for nonclinical psychologists in industry continues to grow under the low case (2.0 percent per year), mid case (3.0 percent), and high case (4.0 percent). This compares to an historical growth rate of 3.1 percent per year for the 1985-1987 period.
- Growth in demand for nonclinical psychologists in the government sector is assumed to be 1 percent annually in each scenario.

Figure 3-5 displays the resulting projections. Total growth in the employment of nonclinical psychologists averaged 3.1 percent annually for the 1973-1987 period; projected employment growth is expected to range from -0.4 percent to 1.9 percent. In all cases nonclinical psychologists engaged primarily in R&D or the management of R&D are projected to remain at a fairly constant proportion (approximately 27 percent) of the total behavioral scientist work force.

Figure 3-6 shows the historical and projected trends in the number of annual openings from death, retirement, and outmobility. Total annual attrition increased from approximately 660 openings in the early 1970s (230 death and retirement and 430 net outmobility) to approximately 1,000 in the late 1980s (430 death and retirement and 570 net outmobility). This level of annual attrition is projected to increase only slightly, to approximately 1,050, for the 1990-1995 period under the mid-case scenario.

As shown in Figure 3-7, the number of job openings per new nonclinical psychology Ph.D. has been between 0.8 to 0.9 for the 1973-1987 period. Assuming degree production changes in parallel with enrollments (-1, 0, and +1 percent annual change for the three scenarios), there will be little change from these vacancy ratios in the 1990s. Even the

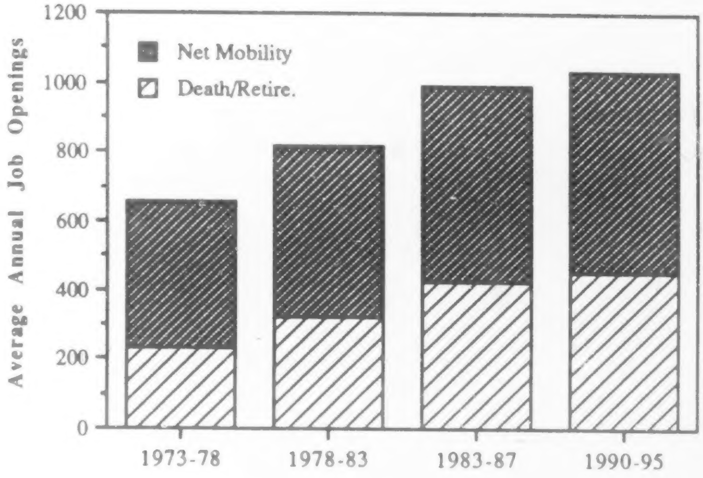


SOURCE: Appendix Table A-20.

**Figure 3-5.** Annual growth rates for nonclinical psychologists, 1987-1995.

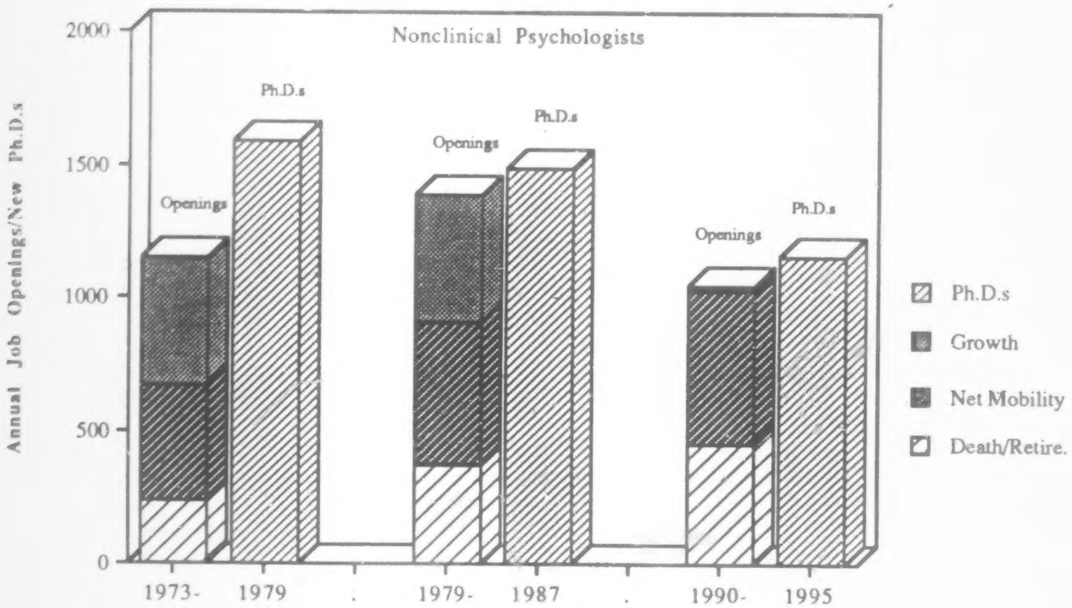
high-case scenario projects approximately one job opening per new nonclinical psychology Ph.D. Taken together, Figures 3-5 through 3-7 show that the labor market for nonclinical psychologists moved from excess supply in the 1970s to approximate balance in the 1980s. This balance is projected to continue into the 1990s, with approximately 80 percent of all job openings coming from attrition.

Projections for nonclinical psychology R&D employment indicate a softening of the job market, with fewer R&D job openings per postdoctorate through 1995 than



SOURCE: Appendix Table A-9.

**Figure 3-6.** Historical and projected average annual attrition for nonclinical psychologists, 1987-1995.



SOURCE: Appendix Table A-21.

**Figure 3-7.** Annual average job openings and new Ph.D.s in nonclinical psychology, 1973-1995.

during the 1973-1987 period, assuming that postdoctorate production remains near its 1987 levels.

In summary, the future labor market for nonclinical psychologists will be characterized by approximate balance unless (1) future rates of growth in employment exceed the high-case scenario rate of 1.9 percent annually; (2) the award of doctoral degrees declines substantially (by approximately 3.0 percent per year) from its current level; and/or (3) the clinical psychology market captures a larger share of nonclinical psychologists. The potential for demand (job openings) in excess of supply (new nonclinical psychology Ph.D.s) is even greater in the late 1990s (see "Prospects for the Long Term," below).

### Other Behavioral Scientists

Other behavioral scientists include Ph.D.s in anthropology, sociology, audiology, and speech pathology. In 1987 other behavioral scientists made up about one in five behavioral scientists. The "other" group is dominated by academic employment: almost 85 percent of total employment is in academic work, with the remaining 15 percent scattered across the other employment sectors.

Given the predominance of academic work, future employment will be closely linked to academic demand. The assumptions used to project future employment, shown in Table 3-2, are as follows:

o Annual growth in graduate enrollment remains modest in all three scenarios: low case (-1.0 percent per year), medium case (0.0 percent), and high case (1.0 percent). As a result, academic employment of "others" grows very little.

o Employment of "others" in nonacademic employment sectors grows more rapidly. The low-, medium-, and high-case growth rates are 7, 10, and 15 percent annually for non-R&D scientists, respectively, and 3, 5, and 7 percent annually for scientists engaged in R&D or the management of R&D.

Figure 3-8 displays the resulting projections. Total growth in the employment of other behavioral scientists averaged 4.8 percent annually for the 1973-1987 period. Projected growth of employment ranges from -0.3 percent to 3.4 percent. In all but the low case, employment in R&D or the management of R&D grows more slowly than non-R&D employment. Attrition is projected to grow to approximately 700 per year for the 1987-1995 period (300 death and retirement, 400 net mobility) from about 650 in the late 1980s. The number of job openings available to each new "other" Ph.D., which had been approximately 0.9 for the 1973-1987 period, would increase only under the high-case scenario. R&D vacancy ratios through 1995 show little change from current values.

In summary, the future labor market for other behavioral scientists will be characterized by relative stability unless (1) the future rate of growth in employment exceeds 2.0 percent annually; and/or (2) degree production decreases from its current level of 950 annually to less than 700 annually.[10] If time to the doctorate in the behavioral sciences continues to grow, degree production could decrease. A combination of these events could also produce a market imbalance. In the R&D sector, movement of postdoctoral students into the labor market at the current level of approximately 120 annually would satisfy long-term R&D demand.

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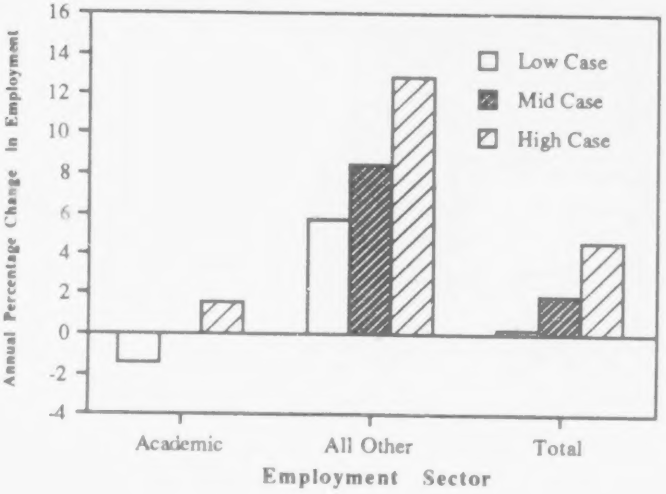
[10] This assumes that degree production changes proportionately with enrollments. First-year graduate enrollments in other behavioral sciences have fallen, from 4,470 in 1980 to 3,995 in 1987. Although the relationship between first-year enrollments and lagged Ph.D. production is poor, these declines could translate into lower Ph.D. output during the 1990s. If this occurs, a portion of this supply shortfall could be absorbed by increasing faculty productivity: in 1975, 5.4 B.A./B.S. degrees in other behavioral sciences were awarded per faculty member; in 1987 this statistic had fallen to 1.6.



SOURCE: Appendix Table A-22.

**Figure 3-8.** Projected annual growth rates for other behavioral scientists, 1987-1995.

The committee's projections of greater growth in demand for biomedical than for behavioral scientists disagrees with the findings of a recent study by Bowen and Sosa. They examined the prospects for arts and sciences faculty and concluded that impending shortages would be greater in the social sciences and humanities than in the natural sciences.[11] One reason for this disagreement is the fact that this report focuses on research personnel and thus excludes the fastest-growing area of the behavioral sciences--clinical psychology. Another is that they make assumptions about changes in student values that our committee did not make.[12]

## THE FUTURE LABOR MARKET FOR PHYSICIAN/SCIENTISTS

### Demand for Clinical Investigators

Estimating the demand for clinical investigators would be a difficult task in the best of circumstances. Terms such as "scientist," "investigator," and "research" are poorly defined and frequently misapplied. Past reports and projections by this committee have taken a similar misstep by virtue of equating "clinical faculty" and "clinical investigators." More recent evidence indicates that the demand for clinical investigators may be lower than previously estimated.

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[11] William G. Bowen and Julie Ann Sosa, *Prospects for Faculty in the Arts and Sciences: A Study of Factors Affecting Demand and Supply, 1987-2012*, Princeton, NJ: Princeton University Press, 1989.

[12] Other relevant differences are that Bowen and Sosa focus on faculty and do not explicitly take account of research. They also use a proportional assumption concerning faculty and enrollment that we consider to be unrealistic: in their baseline case, they find a tighter market as the number of college-aged students stops declining and then begins to increase.

The American Association of Medical Colleges (AAMC) Faculty Roster indicates that 69.6 percent of academic physicians are engaged in research activity, but several studies have concluded that this significantly overstates the number of medical school physician faculty involved in research.[13] Levey, et al., analyzed surveys of faculty in research-intensive clinical departments (internal medicine) and arrived at a figure of 34 percent, later revised (using stricter criteria) to 20 percent. Sherman's reexamination of the same data yielded a *median* R&D effort of 25 percent. Institute of Medicine data, based on seven-day diaries of 3,400 faculty members in 20 schools of medicine and more than 100 teaching hospitals taken in the spring of 1975, indicated that 20 percent were involved in research, either alone or in combination with teaching and patient care; this survey did not include R&D administration as a specific reported item. It seems reasonable, based on these studies, to assume that 20-25 percent of all clinical faculty members would be properly classified as clinical investigators. This places the demand for physician/scientists in medical schools at between 10,000 and 12,000; the total demand would be something on the order of 16,000 to 18,000 (10,000 to 12,000 medical school, 434 NIH, and 5,651 other).

Similar numbers can be arrived at by extrapolating from the NIH-documented population of clinical investigators. Their numbers have increased by 50 percent in the last 17 years, from 4,300 in 1970 to 6,400 in 1987, or roughly 2.4 percent per year. This figure would represent a lower boundary on the number of academically-based research M.D.s. Assuming that the ratio of M.D. grantees to total M.D. investigators is the same as that for Ph.D. investigators--15,589 grantees out of 22,751 Ph.D.s in academic R&D--then by analogy there would be 9,330 M.D.s engaged in academic R&D. Because patient-related research is poorly supported by NIH, the figure is probably somewhat higher, plausibly in the 10,000 to 12,000 range suggested above.

New research efforts requiring M.D. training would increase these demand figures to some unknown extent. New, well-funded initiatives in such areas as health services research, outcome assessment, and epidemiology, in both academic and industrial settings, plus renewed interest in occupational and environmental health, would require additional M.D. participation in areas where medical training has traditionally given little emphasis.

All of this suggests that the time has come to take a new look at the clinical investigator demand model, particularly the demand equations, and to develop a more accurate model on a more rational basis. For example, almost 50 percent of medical school revenues now come from patient care sources; this is hardly an indicator of demand for clinical investigators. Medical student enrollment has leveled off, but the mix of faculty effort may be more directly influenced by house staff and fellow enrollments. The clinical scientist employment reported by NIH appears low--where, for example, are Veterans Administration (VA), Food and Drug Administration (FDA), and other federally-employed investigators reported? To reflect how the demand for clinical investigators is created, and how decisions to employ them are made would require a model in which demand is expressed as an explicit function of such variables as NIH intramural and extramural budgets, FDA budget, pharmaceutical industry R&D expenditures, and state research appropriations to medical schools.

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[13] See G. S. Levey, et al., "Postdoctoral Research Training of Full-Time Faculty in Academic Departments of Medicine," *Annals of Internal Medicine*, vol. 109, no. 5 (September 1988), pp. 414-418; Charles R. Sherman, "The NIH Role in Training of Individual Physician Faculty: A Supplementary Analysis," NIH memorandum dated March 30, 1989; and Institute of Medicine, *Medicare and Medicaid Reimbursement Policies Study*, Washington, D.C.: National Academy Press, 1976.

### The Supply of Clinical Investigators

There is no reason to assume that the number of M.D.s available for clinical investigation will increase because of an oversupply of physicians who find patient care less satisfying for reasons of economics, competition, and/or personal preference. For example, the demand for M.D.s in the health care system's bureaucracy is not trivial, and many physicians may decide to become health care executives or take other career paths that have little or nothing to do with their training as M.D.s. Also, in spite of their best efforts, some of them may not have the intellectual wherewithal, imagination, and drive required to compete in the world of clinical investigation. For all of these reasons, it is not logical to assume that research is more attractive than patient care, nor is there any basis to assume a reduction in the research attrition rate.

The current supply model arbitrarily sets a fraction of the total physician manpower supply as the supply of clinical investigators--a procedure that is simplistic to an unsatisfactory degree. Supply also bears some relationship to the students' responses in the AAMC surveys regarding their future intentions, to the proportions that select subspecialty research training, and most importantly, to the opportunities for training and careers in clinical investigation. A more sophisticated supply model, one that has both relevance and some basis in available data, would express supply as an explicit function of such variables as the numbers of medical students, house staff, and fellows; medical student interest in clinical investigation; and training positions in clinical investigation.

It is equally important to recognize how various disciplines change and open up whole new areas that cannot be predicted by these demand and supply functions. Examples include the impact of new diseases such as AIDS, the growing concern over alcohol and drug abuse in our society, and the growing geriatric population with all of their medical and social needs. Further, the demand for outcome assessment of health care from the standpoint of efficiency will also create a demand for more and more physician/scientists who have the tools to address these problems.

## PROSPECTS FOR THE LONGER TERM: 1995 TO THE YEAR 2000

The preceding analysis of the labor markets for biomedical and behavioral scientists focused upon the period 1987-1995. As was discussed in the text, the policy options for this period are somewhat limited, given that the average time to complete the Ph.D. is in excess of eight years--that is, the "policy window" for the 1995 labor market is quite small.

What of the longer term--that is, to the turn of the century? Although the projections become more uncertain, the influence of policy as a corrective mechanism becomes stronger. The following discussion of a "status quo" future is based upon the assumption that the key variables--mainly enrollments, degree production, and employment growth--continue on the paths established during the late 1980s.

### Biomedical Scientists

If recent trends in employment growth (4.1 percent annual rate) and attrition continue, job openings for biomedical scientists will exceed 8,000 per year by the year 2000. Replacement of scientists lost to attrition alone would require approximately 2,900 scientists. This is more than double the current level of Ph.D. production in the biomedical sciences, about 4,000 per year. Even if one assumes that growth falls to only 2 percent annually, job openings in the year 2000 would require 5,000 new Ph.D.s.

### Behavioral Scientists

Unlike the market for biomedical scientists, the year 2000 labor market for behavioral scientists appears to be more in line with current levels of degree production. There exists the potential for imbalances in this market if even modest rates of employment growth are achieved during the 1990s; this is certainly a topic that needs to be monitored in the future.

Extending recent trends (2.0 percent annual growth) in nonclinical psychology employment growth through the year 2000 results in annual job openings of approximately 1,900 in that year. Current Ph.D. output of almost 1,400 would clearly be inadequate to meet this level of demand. However, it is the committee's opinion that current rates of employment growth will not be sustained; current levels of Ph.D. output should meet projected employment growth of 1 percent annually during the 1990s.

Employment growth in other behavioral sciences has been virtually nonexistent during the late 1980s.[14] Assuming a 1-percent growth rate results in approximately 1,000 job openings in the year 2000, this is in line with 1987 production of approximately 900 Ph.D.s.

### Physician/Scientists

The current number of employee physician/scientists is estimated by the committee to be in the range of 15,000 to 20,000. Given historical trends in public and private biomedical R&D funding, it is probable that demand for physician/scientists will grow substantially in the 1990s.[15] However, it is difficult to project accurately the long-term labor market for physician/scientists because of the data deficiencies cited above. In addition, if demand for basic biomedical scientists continues to grow (as the committee projects), it is possible that physician/scientists will be asked to supply some of the basic science research effort in the biomedical field. The committee's recommendation to examine the issue of post-M.D. basic science training is consistent with this scenario (see Chapters 4 and 5).

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[14] Estimates from the Survey of Doctorate Recipients for total employment of other behavioral scientists was 12,478 in 1983 and 12,736 in 1987.

[15] Real funding for health-related R&D has been doubling approximately every 12 years since 1960. See Table B-7 in Volume II of this report.

# CHAPTER 4

# TOWARD MEASURING THE EFFECTIVENESS OF NRSA TRAINING PROGRAMS

## OVERVIEW

NRSA personnel programs are designed to ensure the adequate supply and quality of biomedical and behavioral researchers. The principal mechanisms are fellowships, which influence individual career choices, and training grants, which also strengthen institutional training capabilities. However, the complexity of these NRSA programs, as well as methodological and data problems, makes it difficult to measure their effectiveness.

Recent studies of NRSA programs at NIH do suggest that participants outperform non-participants in terms of subsequent involvement in research during their careers. These differences held for a wide variety of performance measures, including grant applications, grants received, publication counts, and citation counts. It cannot be concluded from the studies, however, that the training programs were responsible for these differences. There have been no such evaluations of NRSA programs at ADAMHA or the HRSA.

Much of the information needed for more rigorous evaluations is available in existing data sets. Other information could be gathered through surveys of former participants. More information is needed on the determinants of a research career and on the process used to select trainees. The biggest methodological problem is the lack of adequate control groups.

In the case of physician/scientists, program evaluations are more complex. Few M.D. trainees go on to careers of bench-level research, yet their clinical research is vital in applying new knowledge of molecular biology to patient care. Several reports have recommended changes in the program of study in training grant programs for physician/scientists.

### Background

This chapter considers the two most advanced pools in the education pipeline: predoctoral and postdoctoral educational programs in biomedical and behavioral science.[1] The intent here is to examine how effective the National Research Service Award (NRSA) programs are in training individuals who move into successful research careers that meet national needs. A related concern is the question of how variations in effectiveness are related to program substance. With credible information about program effectiveness, plus more refined and thorough versions of the cost data presented in the Executive Summary, it will become possible to determine whether these programs demonstrate acceptable cost/effectiveness.

The committee was aware from the outset that it would be impossible to provide definitive information about the effectiveness of these training programs because of insufficient time and inadequate prior research and data bases. Our more realistic ambition was to derive a program of research and data improvement that, when implemented, could provide important steps toward definitive evaluations.

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[1] We consider the words "training" and "education" to be synonymous, but the term "training program" in the context of this report often refers to specific educational efforts and participants supported in part by the National Institutes of Health (NIH) or Alcohol, Drug Abuse and Health Administration (ADAMHA) funds. In this context, training programs may be considered distinct from fellowship programs.

### The Education Pipeline

Vital national interests require adequate supplies of highly qualified health-related scientists. As was stressed in the Executive Summary, our education pipeline--from elementary schools to universities and professional schools--is the key mechanism for assuring both the adequacy of the supply and its quality. Public policy must focus on effective and efficient ways to ensure that the highest quality and appropriate numbers of scientists are produced by the pipeline while at the same time containing costs.

However, the complexity of producing new entrants into science makes it difficult to affect the course of the process. In addition to being leaky, the U.S. educational system is decentralized, ill-coordinated, and only loosely coupled. In an ideal world the lower levels of an educational system would guide properly prepared young people toward the universities and colleges. These institutions would in turn provide basic scientific training to especially talented young people and encourage them to pursue scientific and professional training and apprenticeships in graduate and professional schools. In that perfect educational system, every young person who showed promise would advance along the pipeline promptly and in proportion to their promise.

In reality, however, local school boards run primary and secondary schools under loose state coordination, universities operate under a variety of jurisdictions, and science departments enjoy a remarkable degree of autonomy within universities. In this less-than-ideal world, therefore, the choice points that move one toward scientific and professional occupations are unclear, both to students and to educational institutions. This lack of clarity, together with the cumulative nature of the pipeline, makes it easier to get out than to stay in. A second result of this uncoordinated educational system is that policies directed at just one of the critical points cannot produce maximum effects, because the processes taking place at any one critical juncture only partially control the total production scheme. The only exception may consist of policies directed at the last stage--graduate and professional schools. Even though the flow is smallest at this point, the degree of leakage appears to be among the largest. Policies that stem this leakage could simultaneously affect improvements in the quality of training.

This discussion requires two caveats. First, even if new pipeline policies are implemented, their effects may take years to become discernible because of the length of the pipeline. Second, as in other areas of human behavior, public policy may be only a minor factor in shaping the flow of personnel into the work force of science; endogenous processes dominate the shaping of that flow. As a result, the effects of policy innovations may be slight and will be manifested only over long time periods. Their detection requires very sensitive measurement, and their analysis needs sophisticated research.

## THE AIMS AND EFFECTS OF TRAINING AND FELLOWSHIP PROGRAMS

The overall goals of NRSA personnel programs are easier to state than to achieve. As a matter of policy, they are intended to ensure that the *supply* of biomedical and behavioral research personnel is sufficient to meet the demand, that their *quality* is high enough to meet the needs of a constantly improving level of biomedical research, and that the *pool of skills* is responsive to shifts in the demand for various kinds of specialized personnel.

To reach these goals, the policy uses a number of devices whose adoption is based on assumptions, explicit or implicit, concerning how occupational choices are made, how biomedical research skills are acquired, and what the market for biomedical research personnel will be. It is useful to examine the first two sets of assumptions to see how closely they match the actual programs pursued and to consider the alternatives to those assumptions that were not adopted. (Labor market issues were considered earlier in this report.)

### Occupational Choice

The most direct goal of NRSA programs is to influence the occupational choices of potential research personnel. The implicit model is that critical choices at each point in the career path are influenced by the balance between anticipated benefits and costs of alternative paths. NRSA programs are designed to influence the balances by lowering costs of particular choices through stipends.

The effectiveness of this strategy depends not only on when the stipend is offered, but also on the array of alternative choices offered by the environment. In many engineering fields, for example, graduate stipends must compete against immediate employment as a B.S. engineer. Similar competitive circumstances face fellowship programs designed to recruit M.D.s into research.

### Training

Another purpose of NRSA programs is to provide students with training opportunities that may not otherwise be available to them. (In this context, training is meant to cover both formal course work and apprentice-like participation in research.) This purpose can be achieved in two ways: either by enhancing the ability of academic departments to provide training, or by improving the range and quality of training choices available to students.

Training grants may be best at enhancing institutional training capacities, for instance by expanding the number of traineeships, providing a departmental focus, or enhancing opportunities for cross-disciplinary training and research. However, it is an open question whether trainees receive different educational experiences than other graduate students in the same departments. Stipends may release students from the necessity to support themselves by unrelated employment, but traineeships may also compete with employment that is directly related to training, particularly research assistantships in which graduate students directly participate in faculty research as apprentices. It is unclear whether the quality of training is affected by being employed as a trainee rather than as a research assistant.

Fellowships awarded to individuals provide fewer advantages to departments, but they too enhance training opportunities for individuals and may also enhance the research of the faculty sponsors.

### Training Efficiency

All other things being equal, the shorter the training period, the more research personnel can be produced. Traineeships and fellowships are believed to shorten the training period by making it less necessary for their incumbents to engage in income-generating activities that are not training opportunities: the more time devoted to training, the quicker it is attained.

Several caveats must be taken into account in assessing this argument. First, the greater efficiency of the entire biomedical and behavioral research personnel "industry" can only be attained if there are qualified and promising candidates for training who cannot be accommodated by the industry's capacity. Second, stipends are fungible--they can substitute for job earnings unrelated to training, but they can also increase the consumption of goods and services or even prolong one's stay in a training position. The fungibility of stipends also allows departments to use stipends to substitute for other funds, thereby increasing the resources available for other purposes or, more likely, increasing the number of graduate students. The connection between traineeship or fellowship strategies and increased efficiency is not necessarily causal except where expansion is required as a condition for awarding a grant.

### Honor

Because fellowships and traineeships are awarded mainly in competition, they honor those who win the awards and hold the resulting positions. Honor may affect subsequent performance by increasing self-esteem, self-confidence, and the expectations of others. This effect may be reduced if traineeships are doled out in the same manner as other support, while fellowships awarded by national competitions may carry additional honor.

### Merit-Tested Selection

Traineeships and fellowships presumably go to the most promising among the pool of eligible candidates. Ironically, those most likely to be selected are also those most likely to become biomedical researchers without the traineeship or fellowship in question. As a result it is difficult to estimate the net effects of biomedical and behavioral research personnel programs. If every promising candidate receives some support, there will be no available controls--no persons of equal merit who were not chosen. (Statutorily ineligible persons, such as foreign nationals, differ from those chosen in other important respects.) Programs that use merit-tested selection can only be evaluated for their net effects by drastically altering the selection process in what may be regarded as undesirable ways. It might be tempting, for example, to randomly deny fellowships and traineeships to selected persons in order to form controls, but such a strategy would surely produce both unsatisfactory controls and strong opposition.

### Marginal Effects

A final policy concern is the marginal effects of the programs: how much would be gained from expanding the program? Marginal effects are especially of interest for programs that are not likely to be terminated, have not reached saturation coverage, and in which policy concerns center around whether the program should be expanded (or contracted). Biomedical and behavioral research training programs are unlikely candidates for termination, but their level of support does sometimes come under scrutiny. The issue of coverage saturation is not settled: there may or may not be additional traineeship or fellowship candidates who are qualified for support. The import of this discussion is that, whatever estimates are made of the effects of the biomedical research personnel programs, attention should be given in the first place to its marginal effects in preference to estimates of main effects.

## THE EVALUATION OF TRAINING AND FELLOWSHIP PROGRAMS

Recent evaluation activities related to the NRSA programs have addressed the above questions and serve to identify areas of highest priority for future research. (A detailed discussion of these activities is found in the commissioned paper by Georgine Pion, found in Volume III of this report.) Such evaluations may serve two different purposes: definitive or descriptive. That is, an evaluation may aim at a definitive statement describing the effects of a program (i.e., a statement of how the world would be different if the program did not exist and evidence of the truth of that statement that is sufficiently rigorous to be acceptable to the scientific community). This requires well-designed research: the programs may have small effects, delayed effects, effects that differ for different subpopulations and under different conditions, and control groups are difficult to find. There has been no evaluation of an NRSA program to date that would meet reasonable scientific standards for a demonstration of causality.

Recent evaluation activities have instead sought the much more modest goal of providing some facts about certain aspects of the program. Most were outcome studies that examined selected aspects of the subsequent careers of recipients and compared them to persons who did not receive NRSA support. These outcome studies are reviewed in the next section, as are the gaps in knowledge about NRSA that appear important to fill. These evaluations do not include any causal inference, but they can still support judgments about the attributes of appropriate policy. For example, if practically all graduates of a particular training program have outstanding research careers, it may be judged good policy to continue the program, even if the program had no causal effect on its recipients' careers. If on the other hand very few graduates of a program ever enter research, it may be judged that the program is not worthwhile, even if the program does have a causal effect on those who do succeed. Most evaluations fall between these two extremes.

**Outcomes**

What happens to persons who receive research training support from the NRSA program? Recent attempts to answer this question focused on indicators of whether the graduates are engaged in health-related research and measures of scientific productivity (e.g., grant application data, publications, citations).[2] These studies typically construct a "comparison group" of persons who did not undergo NRSA training, with which to compare the performance of those who were in the NRSA program. In practice, however, comparison groups have been poorly matched; perfect matching is likely to be impossible. This methodological problem weakens the conclusions that might be drawn about the effect of NRSA training programs on performance differences.

The consistent finding of almost all of the evaluation studies is that NRSA awardees outperform comparison group members in terms of research involvement during their careers. The magnitude of the difference between participants and the comparison group depends in part on the composition of the comparison group. For example, Coggeshall and Brown used two groups for comparison with those who received pre-Ph.D. support under NRSA.[3] The first group consisted of age-matched Ph.D.s who received their degrees from departments that had received an NIH training grant but who had not received an NIH stipend themselves. The second comparison group consisted of Ph.D.s who had received their degrees from other departments and who had not received NIH support themselves. The study found that the performance of participants in NIH-sponsored predoctoral training modestly exceeds the performance of nonparticipants from the same departments and greatly exceeds the performance of the second comparison group. This was true for a wide variety of performance measures, including postdoctoral research support, subsequent involvement in NIH research, publication counts, and citation counts. Given that the first comparison group should have received exactly the same graduate education as the NIH trainees, the differences suggest that at least some training grant directors are effectively selecting their better Ph.D. students for the NIH award.

A second study found that NIH post-Ph.D. awardees also go on to have more research-intensive careers than do members of two comparison groups: (1) biomedical science Ph.D.s who indicated on a survey that they planned to take a postdoctoral appointment but did not receive NIH support and (2) biomedical science Ph.D.s without postdoctoral plans.[4] Again, the differences appear on many performance measures (grant applications, publication counts, citation rates) and were much greater for the second comparison group than for the first.

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[2] For an extensive discussion of the concept of productivity, see the paper by Helen H. Gee in Volume III of this report.

[3] Porter Coggeshall and Prudence Brown, *The Career Achievements of NIH Predoctoral Trainees and Fellows*, Washington, D.C.: National Academy Press, 1984.

Garrison and Brown also studied the post-training performance of NIH M.D. postdoctoral awardees. Here, because research is unlikely to be the career goal of a physician, there are substantial problems in developing an informative comparison group. Comparison data were collected for (1) all M.D.s and (2) a subset of M.D.s who said, a few years after their degree, that their primary activity was either research or teaching. Not surprisingly, the proportion of NIH M.D. postdoctoral awardees who were engaged in research or teaching exceeded that of the typical physician. The subsequent research involvement of M.D.s who had received an NIH fellowship also greatly exceeded the comparison group of self-identified researchers and teachers. However, M.D.s who had received NIH postdoctoral support under a training grant were *less* likely to be involved in research than the comparison group of self-identified researchers and teachers. This unexpected result merits replication; if the finding is repeated, it merits further investigation as part of a program of research into outcomes of NRSA training programs.

A more interesting question is how these outcomes are related to program characteristics. The best information would let one estimate how outcomes for NRSA trainees would change if small amounts of funds were shifted among programs (e.g., from institutional training grants to fellowships awarded to individuals). Training grant programs and individual fellowship applications are assigned priority scores to describe the scientific merit of each application; and (in most NIH programs) funding decisions for each award are made in priority score order. The "payline" is the point at which funds run out. If the outcome for persons who receive training under an application that is close to the payline for each type of grant were known, then one could estimate how the outcomes for NRSA trainees would change if small amounts of funds were shifted among programs. However, none of the studies addressed the relationship between outcome and the priority score given to the fellowship or training grant application.

There is some information about the average outcome for recipients of various components of the NRSA awards. It is important to compare only programs with a reasonable chance of having comparable results. For example, one must expect that post-Ph.D. programs will produce a higher return in researchers per trainee than predoctoral programs because of the greater commitment to research demonstrated by those persons who have successfully completed the Ph.D. and applied for a postdoctoral appointment. Also, because the current M.D. curriculum provides little research training, one must expect a greater return in researchers per trainee from post-Ph.D. programs than from post-M.D. programs. To do better it would be necessary for selected M.D.s to have had enough research experience to be similarly committed to a research career. (See page 58, "A Special Note on the Training of Physician/Scientists.")

The most comparable programs are training grant and fellowship programs aimed at persons with the same previous research training. The few evaluation studies that addressed this issue found that fellows outperformed trainees on most measures of subsequent research involvement. The differences were less pronounced for Ph.D.s than for M.D.s, however: 62 percent of post-Ph.D. fellows applied for an NIH or ADAMHA research grant, compared to 52 percent of post-Ph.D. trainees; for M.D.s, the corresponding figures are 43 percent for fellows and 17 percent for trainees.[5]

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[4] Howard Garrison and Prudence Brown, *The Career Achievements of NIH Postdoctoral Trainees and Fellows*, Washington, D.C.: National Academy Press, 1986.

It would be desirable to know how outcomes are related to other aspects of the NRSA program. The section on the training requirements for physician/scientists (below) notes the empirical evidence supporting the hypothesis that the length of time spent in postdoctoral research training is a strong predictor of the subsequent research involvement of M.D.s. What is not known, however, is the amount of time M.D. recipients of NRSA awards spend in research training supported by non-NRSA mechanisms, such as privately supported fellowships.

There also have been no adequate studies of the outcomes of two of the most promising (and expensive) ways of training physician/researchers: the Medical Scientist Training Program and the Physician/Scientist Award program. Because they both provide longer periods of NIH-supported research training, they may also yield substantially higher returns to research than the more traditional fellowship and training programs, but the facts currently are unknown.

Most evaluation activities have focused on NRSA programs administered by NIH. The few studies that included ADAMHA awardees tended to use fewer outcome measures. There have been no evaluations of the NRSA programs sponsored by the Health Research Service Administration. Similarly, there have been no evaluations of the effect of training grants on the training capacity or training efficiency of recipient institutions.

**Data Needs for Program Evaluation**

Program statistics on the number and characteristics of persons receiving each type of award are the most basic information about the training received by NRSA recipients.[6] To provide this information, NIH sponsored the creation of the Trainee Fellow File, which provides information on all NRSA students, and the Consolidated Grant Application File, which contains information on programs for advanced research training and on institutional awards. One deficiency in these data bases is the difficulty involved in constructing definitions of attributes, such as field of study, that will provide consistent time series. A second problem is the lack of information about program outcomes. A third deficiency is the lack of a set of adequate measures for career outcomes, including scientific productivity. The proposals for a framework for evaluating program effectiveness and for an evaluation data matrix (discussed below) would remove many of the difficulties involved in the use of these data.

The evaluation matrix proposed in the appendix would deal with the ease of use of currently available statistics. However, there are three areas where all currently available statistics are inadequate: research participation by physicians,[7] non-NRSA sources of support for research training, and program evaluations by former trainees. In many medical schools the faculty roster conducted by the Association of American Medical Colleges (AAMC) is not answered by the individual faculty member; as a result, the information in the survey is frequently out of date or otherwise inaccurate. The only firm information available on the amount of time that physicians spend on research comes from a one-time survey of the faculty of departments of internal medicine.[8] Information is lacking on other specialties.

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[5] Garrison and Brown, *op. cit.*, Tables 4.2 and 8.2A.

[6] See the appendix for a further description of existing and proposed data sets discussed in this chapter.

[7] Research participation by Ph.D.s is covered in the SDR.

Information about sources of support would be obtained most accurately from a survey of the training sponsors, although it could also be collected on an individual basis. This information would give a more accurate picture of the total training received by NRSA recipients and would greatly facilitate the design of more effective evaluation studies.

Some outcome measures are available from data sets such as the SDR and the Institute of Scientific Information's Science Citation Index. Other basic measures are available only from former trainees themselves (and, where appropriate, from credible comparison groups). Former trainees' assessments of the impact of NRSA training on their subsequent careers is just one basic set of information that could be of substantial value in future versions of this report. Other valuable items would include sense of satisfaction with one's career and sense of contribution to the field. Because the SDR is based on a small sample, it is usually inappropriate as the source of inferences about small populations such as NRSA trainees in a given field of science. In this case, occasional surveys of former trainees and appropriate control groups are altogether warranted.

Very little is known about the process used to select trainees for institutional grants. No records are kept of unfunded applicants or of persons who are offered a traineeship but turn it down. The lack of such basic information about the demand for training makes it difficult to assess important parameters of the program, such as the level of stipends and the effects of the payback provision.

Finally, and perhaps most importantly, there is a great need for basic research on the determinants of a research career. NRSA programs attempt to intervene in a complex decision process that is poorly understood. Little is known about how the characteristics of a training program affect the research abilities of persons who participate in that training.[9] Although the recent evaluation studies suggest that NRSA training is correlated with success as a researcher, the correlations are very small: the total effect of NRSA training and other indicators of preexisting quality explained only 6-14 percent of the variance in outcome measures. Better understanding of the factors that influence career decisions and research ability is the key to designing more effective and efficient training programs.

## A FRAMEWORK FOR PROGRAM EVALUATION

There are two major limitations in conducting an adequate evaluation of NRSA programs: (1) inadequate control groups with which to compare the awardees and (2) inadequate measures of many of the outcomes that need to be assessed. As discussed above, the problem of control groups is related to the process by which trainees are selected: those selected might have more successful careers (by whatever measure) than those not selected, independent of the advantages provided by the training program. An ideal experimental design would consist of choosing trainees randomly, independent of their characteristics, so that differences in career outcomes could be attributed to the effect of the training program. This ideal methodological approach is unreasonable in practice. A reasonable and practical alternative to random selection would be careful study of the process that determines selection as an NRSA trainee. This approach would also provide insights that can be used to improve the selection process and, to the extent that the process is modeled adequately, it would be possible to introduce statistical controls into the analysis of the effects of being a trainee on career outcomes. Consequently, the committee's first recommendation in designing future evaluation studies is to include detailed information on the process by which trainees are selected from all applicants. The next step is to model the effects of the training program on career outcomes, including productivity measures.

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[8] G. S. Levey, et al., "Postdoctoral Research Training of Full-time Faculty in Academic Departments of Medicine," *Annals of Internal Medicine*, vol. 109, no. 5 (September 1988), pp. 414-418; their findings are discussed in Chapter 5 of this report.

[9] Coggeshall and Brown, *op. cit.*; Garrison and Brown, *op. cit.*

The commissioned paper by Helen H. Gee (see Volume III of this report) establishes guidelines that should be used in planning productivity assessments, including a number of general points about the use of productivity measures for NRSA programs:

- Define program goals specifically enough to provide guidance in constructing measures of their success. For example, "contribute to the research enterprise" does not narrow down the many ways this can be accomplished--through publications, patents, administration, and teaching.

- Recognize multiple pathways (activities and career paths) that can lead to those goals by designing evaluation studies that assess the variety of potential outcomes.

- Exclude those scientists whose career paths and research productivity cannot be assessed adequately with available methods and data. For example, if methods for assessing the productivity of nonacademic scientists are not practical, those scientists should be excluded from comparisons of other groups.

- Identify the uses to which the results of the assessment are to be put and let them guide the design of evaluation studies. Evaluations designed to assist program managers, for example, will not necessarily provide the information required by those making policy decisions.

Recent evaluation studies have tended to focus exclusively on the single measure of publications and the single characteristic of whether or not the trainee sought funding from NIH. The committee recommends that future studies consider a broader spectrum of outcome measures, including the following:

- receipt of a Ph.D. (for predoctoral trainees);
- time required to complete the Ph.D. (for predoctoral trainees);
- years of postdoctoral training;
- type of employer;
- type of work activity;
- pursuit and receipt of NIH and ADAMHA funding;
- publications and citations; and
- area of research.

For the evaluations to be most effective, these measures (many of which have been used in other studies) should be followed over an extended period of the career rather than be measured only at a single point in time. Longitudinal studies should be used that track changes in employers, work activity, grant activity, publications, citations, and area of research over at least the first decade of the career. Statistical comparisons of the career activities of trainees and the control group will provide a much better insight into the effectiveness of NRSA training programs.

In summary, it is possible to design and carry out research that will produce unbiased estimates of marginal program effects by carefully expanding the program to include additional trainees and fellows. Persons selected under this controlled expansion need to be followed over a period of time. Furthermore, the heterogeneity of the programs' aims and mechanisms also create difficulties because there are many kinds of intended effects and additional side effects--some desirable, some simply benign, and others possibly subversive of the main aims of the programs. Thus, the committee recommends that two evaluations of program effects be undertaken:

1. A comprehensive assessment of the effects on institutions, departments, and individual trainees and fellows and

2. A less comprehensive evaluation of the effects of program participation on individual awardees.

## A SPECIAL NOTE ON THE TRAINING OF PHYSICIAN/SCIENTISTS

Program evaluation for clinical investigators is further complicated by the complexities of training and tracking the academic physician/scientist. M.D. faculty are supported in their research training not only through NRSA fellowships and institutional training grants, but also by a variety of foundations and volunteer health agencies. Thus, receipt of NIH support for post-M.D. training and receipt of post-M.D. training are not synonymous.

Evaluation is further complicated when application for and receipt of NIH research grants (generically called R01) by former trainees are used as program outcome variables. The subsequent careers of M.D. awardees may involve (1) no research, (2) bench-type research, or (3) academic "hands-on" patient research. It is predominantly those in the second category--a comparatively low number--who are likely to apply for and obtain NIH R01 research support. Yet there is evidence that far more M.D. faculty in the third category--perhaps as many as 50-60 percent of the total NRSA M.D. trainees--are doing productive clinical investigation but not at the bench level that is generally required for NIH R01 funding.

There is a vital need for well trained clinical investigators who can take the enormous explosion of knowledge in molecular biology and apply it to the care of patients. Over the last decade, however, it has been increasingly difficult for clinical investigators doing hands-on patient research to obtain funding through NIH. These individuals may account for a very large proportion of the "unsuccessful" trainees from the NRSA institutional grants. If so, they must be identified and quantified for adequate program evaluation. The same holds true for the cadre of clinical investigators who will have to be trained in the methodologies of epidemiology, biostatistics, health services research, economics, and outcome assessment in the near future.

James Wyngaarden, a former director of NIH, has emphasized that research training and career development programs have a priority for NIH "virtually equal to the support of research project grants."[10] He also acknowledges, however, that NIH-sponsored training programs have variable success rates, with the least certain being the traditional training programs for physician/scientists. Far too few of these M.D. trainees apply for and receive NIH research grants, according to Wyngaarden, and some training programs merely serve as support vehicles for subspecialty clinical training. He calls for a comprehensive, critical review of NIH research training programs, specifically whether examining current training programs for physician/scientists should be modified.

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[10] J. B. Wyngaarden (memorandum to BID Directors and OD Staff), "Review of NIH's Biomedical Research Training Program," April 19, 1989.

Wyngaarden's position is echoed by Lloyd H. Smith (see Volume III of this report). Smith's position is that the serious physician/scientist must receive in-depth training in a scientific discipline relevant to medicine and that rigorous scientific training can rarely be achieved in a specialty division of a clinical department. Smith argues that the training of physician/scientists should be comparable to Ph.D. programs in rigor and scope and that the physician should not be burdened with clinical responsibilities during the research training period. Smith believes that at least three years of rigorous training in modern biological science is usually necessary for most individuals to achieve independence as an investigator.

Smith's paper buttresses remarks made by Joseph Goldstein in his 1986 address to the American Society for Clinical Investigation. Paraphrasing from that address, intelligence, curiosity, and drive are necessary but not sufficient for the productive physician/scientist; there must also be technical skill and the ability to reduce a complicated clinical phenomenon to a manageable biochemical problem.[11] Given the complexities of modern biomedical research, a clinical investigator must have a sophisticated understanding of the fundamental sciences, a mentor in the sciences to direct development, the opportunity to learn techniques, and uninterrupted time in the laboratory to conduct the research.

Those committee members who have experience in the training of physician/scientists endorse the suggestions made by Smith and Goldstein and suggest that the following changes be made in the postdoctoral institutional training programs for physician/scientists:

- a true consortium between the clinical and preclinical departments of the institution, with shared responsibility for the design and administration of the program;
- selection of trainees based on evidence of some previous experience in research and overall promise;
- formal course work in the physical and biochemical sciences sufficient to give graduates a theoretical background comparable to those with graduate degrees in the biological sciences;
- not less than three years of research training, primarily in direct research experience under the supervision of a mentor; and
- modules of instruction, specifically tailored to the needs of the physician trainee, in such areas as basic laboratory techniques, chromatography, radioimmunoassay, protein purification, advanced instrumental techniques, fundamental principles of enzymology and molecular biology, subcellular fractionation techniques, computer technology, evaluation of experimental data, epidemiology, and statistics and data base management, as well as grant and manuscript writing.

A 1986 survey of full-time faculty in departments of medicine made similar recommendations regarding postdoctoral research training.[12] The survey identified several features of training experiences that were associated with the faculty member currently being an active researcher, including the following:

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[11] J. L. Goldstein, "On the Origin and Prevention of PAIDS (Paralyzed Academic Investigator's Disease Syndrome)," *Journal of Clinical Investigation*, vol. 78, 1986, pp. 848-854.

[12] G. S. Levey, et al., *op. cit.*

1. Most postdoctoral training occurred in medical schools and the primary source of funding was NIH.
2. For faculty members with an M.D. degree, the length of training was a significant predictor for subsequently being an active researcher and principal investigator for a peer-reviewed research grant.
3. The average length of time between the end of postdoctoral research training and obtaining the first peer-reviewed research grant was 24 months, regardless of length of training, source of training support, training site, or type of academic degree (M.D., M.D./Ph.D., or Ph.D.).
4. Respondents advocated incorporating formal course work, particularly in the basic sciences and statistics, within the structure of the postgraduate training programs, with less time allocated to patient care.
5. Contributing factors to being a successful researcher in academic medicine include the following: two or more years of postdoctoral research training, including formal course work in the fundamental sciences pertinent to biomedical research; two to three years of full research funding from an academic institution until the first extramural grant is obtained; and the investigator's commitment of at least 33 percent of time to research activities.

The former trainees, upon reflection, favored changing the curriculum to include more formal course work and training in fundamentals, particularly mathematics/computer science, statistics, research techniques, grant administration, and medical writing. Of equal interest, the vast majority (65 percent) wanted less time devoted to clinical medicine during the training program. The committee as a whole finds merit in these suggestions and recommends that NIH establish a committee, conference, or study to consider whether changes should be made in the program of study in postgraduate institutional training grants for physician/scientists.

Deficiencies in the evaluation of these training programs are described in detail in the commissioned paper by Georgine Pion (see Volume III of this report). There are inherent difficulties in retrospective survey designs, and evaluation must focus on the career development of those who trained as many as 10-15 years ago to determine long-range effects of these training programs. The evaluation must also define what constitutes "success." For example, although this committee may conclude that institutional training grants need to be revised, it also recognizes that even in their current form, these programs have made a positive contribution. Graduates of the institutional training grants have populated all the clinical departments in our medical schools and, even during their short training periods, they have done valuable research work in the laboratories of established investigators.

# Chapter 5

# RECOMMENDATIONS

## LEVELS OF NRSA SUPPORT

### Basic Biomedical Sciences

The key findings are as follows:

1. The number of biomedical Ph.D. awards and labor demand (job openings) have been in approximate balance since the early 1980s; the ratio of job openings to new Ph.D.s is expected to increase through the year 2000.

2. Industry is and will continue to be the dynamic sector for employment growth with the majority of new vacancies occurring in this sector.

3. The growth rate for research and development (R&D) employment will exceed that for total employment for the foreseeable future. This is due in large part to the relative growth of the industrial sector, whose biomedical Ph.D.s are heavily involved in R&D.

4. Women are a growing proportion of the biomedical labor force. Given that women are less likely than men to be involved in full-time science, their increasing participation may lead to higher outmigration and less effective labor supply.

Based on these considerations, the committee recommends shifting the NRSA program towards Ph.D. production. This could be done in three ways:

1. *Increase the level of predoctoral support.* There is evidence that enrollments in the biomedical sciences are very responsive to increasing student support.[1] The committee recommends that the level of predoctoral support be increased to 5,200 from its current level of 3,681 full-time equivalent positions.

2. *Improve the graduation rate of Ph.D. candidates.* This would have a substantial impact on labor supply.

3. *Decrease the time needed to complete the doctorate.*[2] There is evidence to suggest that student support during the thesis considerably shortens this time.

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[1] It has been estimated that first-year biomedical Ph.D. enrollment increases 1.35 percent for each 1-percent increase in the number of students who have support. See Joe G. Baker, "The Ph.D. Supply Crisis: A Look at the Biomedical Sciences," paper given at the Western Economics Association Meetings, June 21, 1989, Lake Tahoe, Nevada.

[2] The increasing time to the doctorate has hampered Ph.D. labor supply in two ways. First, it has retarded the labor supply response to such stimuli as increasing wages and student support. Second, it has increased the investment costs of graduate education, resulting in lower enrollment. See Joe G. Baker, *op. cit.*

The committee suggests that NIH examine the potential utility of a program tailored specifically for student support during the thesis-writing stage.

Needed levels of postdoctoral training support will depend upon (1) the requirements of industry for this level of training and (2) decisions as to whether the public sector should support postdoctorals for industry. If the demand/supply balance that existed during the early 1980s is to be maintained, total postdoctoral support must increase from its current level of approximately 8,200 to around 11,500. The current level of NRSA postdoctoral support, around 3,700, should be increased gradually as the number of Ph.D. degrees increases.

Serious questions have been raised about whether postdoctoral training represents a useful added educational experience designed to enhance productivity, or whether instead it is merely a holding tank for those doctoral scientists who are unable to land a suitable job.[3] Evidence on this issue is sufficiently flawed by methodological problems as to leave it an open question about which convincing research is needed. A suggestive fact revealed in a survey carried out for the committee is that industrial employers of biomedical scientists prefer those with postdoctoral training credentials. The committee believes strongly that postdoctoral training programs in biomedical fields should be retained and even expanded moderately, but recommends thorough program evaluations at both predoctoral and postdoctoral levels.

**Behavioral Sciences**

The following are the key findings:

1. Most of the employment of nonclinical psychologists and other behavioral scientists occurs in colleges and universities. Given the assumption of modest enrollment growth in behavioral sciences, growth in demand for academic behavioral scientists will also be modest.
2. The labor market for nonclinical psychologists and other behavioral scientists has been fairly stable through the 1980s.
3. There is potential for behavioral science demand growth to exceed new Ph.D. supply in the post-1995 period. This is especially true if degree awards continue to fall.
4. Behaviorally-based health problems (AIDS, drug and alcohol addiction, tobacco, cancer, etc.) are increasing in importance. For this reason, it is important to the nation's health that NIH/ADAMHA continue to support behavioral science research and research training.

Given these considerations, the committee recommends that predoctoral and postdoctoral support be kept at their current levels of approximately 500 and 420 full-time equivalent positions, respectively. However, the committee also recommends moving support away from clinical psychology toward nonclinical psychology and other behavioral sciences. The level of support for scholars in the area of health services research should be increased (see below).

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[3] P. E. Coggeshall, et al., "Changing Postdoctoral Career Patterns for Biomedical Scientists," *Science*, vol. 202 (November 3, 1978), pp. 487-493.

**Clinical Sciences**

1. The committee recommends that the current number of trainees and fellows for M.D. investigator training remain essentially as it has been (approximately 2,150). Although the demand for M.D. investigators likely will increase, the committee feels that proposed studies of the training mechanisms and training outcomes for the various programs should be carried out before significant changes are made. It is hoped that these steps will be taken soon.

2. The level of support for M.D. research training in the area of health services research should be moderately increased.

## DATA IMPROVEMENTS, NEEDED RESEARCH, PROGRAM EVALUATION, AND ADMINISTRATIVE INFRASTRUCTURE

The committee has identified new activities in each of these areas that would improve understanding of scientific personnel issues and improve the quality of future versions of this report. The committee recommends that NIH/ADAMHA put in place the necessary interim staff and begin immediately the programs of data improvement, research, and evaluation proposed below.

**Small-Scale Data Improvements** (not in priority order)

1. *Improve employment specialty information in the Survey of Doctorate Recipients (SDR)*: An important component of the labor market is occupational mobility; this mechanism is a source of both labor supply and demand for new scientists in the biomedical and behavioral fields. It is the opinion of the committee that the list of occupations included for self-identification in the existing SDR survey form is too restrictive and makes it difficult for a Ph.D. who has moved out of science to respond to the survey. As a consequence, it is likely that outmobility from science is understated. This issue needs to be examined with a goal of improving the employment specialty information on the SDR.

2. *Add a salary item in the Doctorate Records File (DRF)*: The DRF is a census of all Ph.D. recipients from U.S. universities, collected continuously as degrees are granted. These data provide information on the new doctorate recipient's plans after graduation (approximately 60 percent of Ph.D.s have definite postdoctoral plans at the time the DRF survey form is completed) The inclusion of an item on expected salary for those with definite plans would give a mechanism for continuous monitoring of the relative tightness of the Ph.D. labor market by detailed fields, quality of degree-granting institution, sector of employment (academic, industry, federal lab, etc.), and other variables. These salary data would provide a baseline for analysis and modeling of the Ph.D. labor market at minimal cost.

3. *Improve response rate and evaluate nonresponse bias of the SDR*[4]: The SDR is the main data set used in the analysis of the Ph.D. labor market. These data are based upon a biennial survey of approximately 10 percent of the U.S. doctorate work force. The survey is plagued with relatively low response

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[4] This recommendation is consistent with that contained in a recent evaluation of the NSF data system. See C. F. Citro and G. Kolton (eds.), *Surveying the Nation's Scientists and Engineers: A Data System for the 1990s*, Washington, D.C.: National Academy Press, 1989.

rates and the attendant possibility of serious nonresponse bias. Two steps need to be taken:

a. Analyze the extent of nonresponse bias. The last such study of these data was conducted in 1979. The committee endorses the recent effort by NSF to update this study, now under way.

b. Assemble an ad hoc committee of experts in survey research methods to design approaches that will improve the SDR's response rate.

4. *Include a postdoctoral identifier in the SDR*: The evaluation of postdoctoral study as a research training method is critical if future policy is to be suggested. The current structure of the SDR makes it difficult to determine whether a scientist has participated in postdoctoral study; the inclusion of a question regarding this activity would allow for a more thorough evaluation of postdoctoral support.

**Larger-Scale Data Improvements** (in priority order)

1. *Establish a program evaluation data matrix*: To assess the numerical adequacy of the nation's biomedical and behavioral research personnel and to make judgments about the quality of their training, we need both quantitative and qualitative information. The data matrix discussed in the appendix could provide such information. The committee recommends that the training data be organized and analyzed as suggested by that data matrix framework.[5]

2. *Reconcile SDR postdoctorate estimates and those of the Survey of Graduate Science and Engineering Students and Postdoctorates (GSESP)*: There are two sources of information on the level of postdoctoral utilization: the NSF/NIH SDR and the NSF/NIH GSESP. These surveys are inconsistent. The ambiguity of these data made it difficult for the committee to determine the historical trends in postdoctoral appointments; this, in turn, made recommendations about future levels difficult. This issue needs to be resolved to improve the analysis and evaluation of the NIH/ADAMHA postdoctoral effort. The effort may require a separate one-time survey.

3. *Improve research identification on the NIH/Association of American Medical Colleges (AAMC) Faculty Roster*: Historically, the main source for data on physician/scientists has been the AAMC Faculty Roster. Subsequent studies have shown that Faculty Roster data are inadequate to define precisely the actual research activities of faculty and the quality of their research effort. A better identification of researchers and their activities must be achieved, in terms of both the AAMC questionnaires to deans of schools of medicine (Faculty Roster) and the NIH tracking of its institutional National Research Service Award (NRSA) training grant awards. Simple identification of self-designated researchers without any effort to quantify the amount and quality of research is meaningless.

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[5] This recommendation is consistent with that of the Task Forces for the Review of NIH Biomedical Research Training Programs. See the NIH "Review of the National Institutes of Health Biomedical Research Training Programs," mimeographed, October 1989, p. xvii.

**Needed Research** (both sets of equal priority)

1. *Studies of recruitment and retention throughout the academic pipeline*: We urgently need more comprehensive knowledge on recruitment to and losses from the pipeline into biomedical and behavioral science, especially about women and minorities at all stages of the pipeline. The committee recommends a program of research, beginning with one or more commissioned papers that summarize and synthesize the literature on the subject with emphasis on the evaluation of intervention programs at critical nodes in the pipeline. Given the anticipated labor shortages in biomedical sciences, improvement of graduation rates and participation in full-time science after graduation are important issues.

2. *Survey studies of former trainees with control groups*: The program evaluations recommended below should contain several novel components relative to the prior evaluations described in the commissioned paper by Georgine Pion (see Volume III). One of these should be a series of surveys of former trainees and of carefully designed control groups. The surveys should concern career outcomes that are not reflected adequately in available secondary data, including job satisfaction and future plans, as well as the success of those in academe as undergraduate and graduate teachers. They should center on retrospective evaluations of their pre- and postdoctoral studies and, for former trainees and fellows, on the value of the programs. Finally, they should tap aspects of the research career that are not available from other sources, such as patterns of research collaboration (locally and at a distance) and sources of research funds other than NIH/ADAMHA.

   These studies can feed into the set recommended above by defining study populations as graduate school entrant cohorts--not just doctorate recipients--who received NRSA support or who had the characteristics of a control group member. If done properly such studies could represent a major contribution, not only to needed program evaluations, but also to our understanding of the determinants and career consequences of attrition from graduate school.

**Recommended Program Evaluations**

The committee recommends two new, large-scale program evaluations that differ from prior efforts by including surveys of former trainees and fellows (see above) and field research that takes investigators onto the campuses at which the selected programs are located. We recommend the careful selection of individual programs within the two training categories for initial evaluation. Program directors, department chairs, trainees, and other students should be interviewed. Curricula should be evaluated and aggregate survey results discussed. We recommend that the first two programs to be evaluated in this fashion be the Minority Access to Research Careers (MARC) and the Medical Scientist Training Program (MSTP). We recommend that the sequence of steps leading to these evaluations parallel those recommended for the two programs of research.

**Interdisciplinary Programs**

The committee urges NIH/ADAMHA to continue to evolve its predoctoral and postdoctoral programs to meet changing national priorities, and we support the need for some of these programs to be interdisciplinary in nature. But it is imperative that those trained in interdisciplinary, cross-disciplinary, or multidisciplinary programs be thoroughly trained in basic disciplines and capable of rigorous work of the highest scientific quality. Recently developed programs (such as biotechnology training) can accomplish these objectives, provided that peer evaluations are sustained at high levels and are based on clearly articulated and applied criteria. This recommendation is based on the committee's firm belief that the solutions to complex health problems, such as the AIDS epidemic, cannot be specified or narrowly targeted. Breakthroughs may come from studies in many basic fields and are likely to be found at the conjunctions of fields. But they will be found only by researchers whose understanding of those fields is deep and who have the flexibility of mind and breadth of training that allow such discoveries to be made.

### Needed Organization with Which to Implement These Recommendations

We recommend that a new committee be activated no later than January 1992 in order to allow two years for the preparation of the 1993 report. If the preceding recommendations are initiated promptly, that report will require two years of effort and should represent a major contribution to our knowledge of scientific personnel. In order that the studies be undertaken and coordinated, there will have to be one or more persons responsible for their administration and possibly research involvement.

### Special Consideration: The Program of Study for Physician/Scientist Research Training

Those committee members with experience in the training of physician/scientists believe that the program of study for physician/scientists, with emphasis on the NRSA institutional training grant mechanisms, must be radically changed to meet the health needs of the nation.

Lloyd H. Smith notes that the science taught in specialty divisions of the clinical departments tends to be goal-oriented and superficial; although some physician/scientists have thrived in the environment and have had productive careers, most have been poorly prepared for sustained scholarship.[6] Smith believes it is imperative for the serious physician/scientist to receive in-depth training in a scientific discipline relevant to medicine and that the training of the serious physician/scientist should be comparable to Ph.D. programs in rigor and scope. The physician should not be burdened with clinical responsibilities during the research training period. Smith believes that at least three years of rigorous training in modern biological science is usually necessary for most individuals to achieve independence as an investigator.

Those committee members who are experienced in the training of physician/scientists support Smith's proposal for such a training program and believe it should contain the following elements:

1. The training program should represent a consortium between the clinical and pre-clinical departments of the institution with joint responsibility for design and administration of the program.

2. Selection of the trainees should be made as early in the academic pipeline as possible, even during undergraduate medical education, if possible, but based on evidence of some experience and overall promise in research. Selection planning can then be coordinated for both basic clinical training and for the subsequent scientific training. The basic science departments and/or programs should participate in the selection process so that their commitment to the individual selected is ensured.

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[6] See Lloyd G. Smith, "Training of Physician/Scientists," in Volume III of this report.

3. Formal coursework in the physical and biochemical sciences, as well as in the epidemiological, biostatistical, and economic disciplines, should also be available and applied for an individual investigator as the need for that discipline arises.[7] The committee members who are experienced in the training of physician/scientists recognize that it is important for graduates of this physician/scientist program to command a theoretical background comparable to that obtained by those with graduate degrees in these various disciplines. Clearly, the extent of required coursework must be individualized based upon the level of prior training, but it must be relevant and rigorous at the graduate level.

4. Such a training program in the sciences, above and beyond what is involved in the subspecialty training events, must be for not less than three years, and most of that must be invested in direct research experience under the direct supervision of a mentor. Completion of this training period, which may often be extended beyond the formal three-year program, would allow physician/scientists to rejoin their respective clinical department for subspecialty training in the chosen disciplines. It is recognized that some may elect to remain in basic science and will enrich those disciplines with their breadth of training and interest in human biology.

Those committee members who are experienced in the training of physician/scientists suggest that over the course of a three-year training period, modules of instruction should be specifically tailored to the needs of the physician trainee.[8] This program of study would provide the physician/scientist with enough scientific depth to sustain a research career for a lifetime and not merely for a limited time beyond postdoctoral research training. Improved training in the fundamentals should also enable the physician/scientist to develop the flexible approach to problem-solving that is critical for successful pursuit of other lines of investigation stemming from observations made during the course of a goal-oriented research project.

The committee as a whole finds merit in these proposals and recommends that NIH establish a committee, conference, or study to address the central issues concerning the program of study in postgraduate institutional training grants for physician/scientists.

### Special Consideration: Health Services Research

Health services research aims to improve the way health care services are delivered through improved use of existing medical technology. It studies the quality, efficacy, and appropriateness of health care services as well as how these are affected by the method of reimbursement, the training of health professionals, and other aspects of the health care delivery system.

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[7] This is consistent with survey results that indicate former postdoctoral research trainees favor changing the curriculum to include more formal coursework and less clinical medicine. See G. Levey et al., "Postdoctoral Research Training of Full-time Faculty in Academic Departments of Medicine," *Annals of Internal Medicine*, vol. 109, no. 5 (September 1988).

[8] These modules could include such topics as basic laboratory techniques, chromatography, radioimmunoassay, protein purification, advanced instrumental techniques, fundamental principles of enzymology and molecular biology, subcellular fractionation techniques, computer technology, evaluation of experimental data, epidemiology, statistics and data base management, as well as grant and manuscript writing.

Health services research is an interdisciplinary activity that requires individuals to be trained in a variety of fields, including medicine, economics, public health, sociology, statistics, psychology, and other fields in the natural and social sciences. In addition, it requires specially trained individuals who are capable of bringing disparate disciplines together to examine questions about the delivery of health services. These individuals receive interdisciplinary training in programs of health services research or public policy analysis. Those whose degree is in a field such as medicine or economics require additional training in the methods and knowledge base of health services research, which is usually received during a postdoctoral period.

Little quantitative information is available about either the supply of or demand for health services researchers, although Elizabeth McGlynn's paper (see Volume III) identifies disciplines for the members of the Association of Health Services Research. The same paper also outlines a research agenda that would provide some important basic information about demand and supply. Because of the interdisciplinary nature of health services research, a study of field migration is central to an understanding of the supply of researchers in the field. How much migration into and out of the field occurs? What factors affect migration rates? How long does it take an in-migrant to become productive? How does migration affect the quality of health services research? A more mundane but nevertheless important evaluation issue is how one should identify a person, a research project, or a training program as being part of the field of health services research.

Although we cannot quantify with much precision the current demand for health services researchers, there is substantial evidence that the demand will increase significantly in the near future. Members of the Congress, the Administration, and the private sector all have expressed a keen interest in obtaining answers to complex questions about controlling the quality and cost of health care. Bills introduced into both the House and Senate would authorize a wide program of health services research activities at a greatly increased level of spending beginning in 1990 (S. 702 would authorize spending $239 million over three years; H. 1692 would authorize $847 million over five years). The Administration has requested increased funding for evaluation research. Many private foundations have been funding pioneering work in this area throughout the last decade, and the insurance industry recently has begun to sponsor research in this area. It seems prudent to increase funding for training in this area so that the research monies will be well spent.

# APPENDIX

Page

The Emerging Biotechnology Industry 89

Data Needs for Program Evaluation 93

Summary of Employment Trends 99

# THE EMERGING BIOTECHNOLOGY INDUSTRY

## SUMMARY AND CONCLUSIONS

The 1989 survey of biotechnology firms indicated that strong employment growth is anticipated for Ph.D. biomedical scientists in the near future. Firms appear to be having problems finding scientists trained in pharmacology, toxicology, immunology, human/animal molecular biology, and industrial microbiology. Biochemistry and chemistry are the largest occupational groups, with almost a third of all biotechnology specialists.

By and large, biotechnology firms are very pleased with the formal academic training of scientists. Two major complaints appear to be the poor oral and written communication skills of new graduates and the lack of a "focused" approach to research. Postdoctoral appointments, especially nonacademic appointments, are viewed by industry as valuable additions to the training process. The postdoctoral experience allows the young scientists to prove their ability for independent research and at least partially moves them toward a more focused research approach. The training implications of this are threefold. First, graduate programs need to pay more attention to developing the communication skills of their scientists. Second, industry appears to desire moving the research training toward applied work and away from basic work. Third, industry would like to see postdoctoral appointments continue as an integral part of the training process and would like to see more nonacademic (industry, foundations, etc.) postdoctoral appointments made.

## SURVEY DESCRIPTION

In 1988 this committee collaborated with the National Science Foundation (NSF) in a joint effort to collect information on the employment of biomedical scientists in the biotechnology industry and in industry in general (hereafter the National Academy of Sciences [NAS]/NSF survey). The survey frame was developed from a list of dedicated biotechnology firms (DBCs)[1] used in a 1987 Office of Technology Assessment (OTA) biotechnology industry survey and updated from a listing of U.S. biotechnology companies as appeared in the *Seventh Annual Genetic Engineering News (GEN) Guide to Biotechnology Companies*.[2] Of a total of 512 firms queried, 71.3 percent returned usable responses. Based on the assumption of no nonresponse bias, the returned survey tabulations were inflated to represent an estimate of the total survey frame.[3] The following discussion summarizes the results of this estimate.

### 1989 Employment

Total 1989 employment in DBCs is estimated at 53,985; of this total, 3,527 (6.5 percent) are Ph.D.-level scientists. The total number of scientists employed by DBCs in 1989 was estimated at 8,937 (16.6 percent of total DBC employment); thus, almost 40 percent of the scientists employed by DBCs hold a doctoral degree. In the NSF general survey of all industry, 0.5 percent of total employment was composed of Ph.D.s; doctorates made up approximately 25 percent of all employed scientists. Scientists of all degree levels comprised 2.2 percent of total general employment. Not surprisingly, the biotechnology industry is weighted heavily toward a Ph.D. work force, reflecting the research and development nature of its business. In 1989 79.5 percent of the scientists in the DBC survey had R&D as their primary work activity.[4]

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[1] DBCs are those companies whose primary line of work is in the biotechnology field. In addition to these firms, large diversified companies exist that have a biotechnology division or laboratory. In 1987, the Office of Technology Assessment (OTA) estimated that total biotechnology employment in the diversified companies was 11,600 compared to 24,347 in DBCs (see footnote 2).

[2] See Office of Technology Assessment, *New Developments in Biotechnology, Volume 4: U.S. Investment in Biotechnology*, Washington, D.C.: Office of Technology Assessment, 1988, Chapter 8; and *Genetic Engineering News*, vol. 8, no. 10, 1988.

[3] The returned survey results were simply inflated by 1,403, which represents the ratio of total survey frame (512) to usable responses (365).

**Occupational Employment**: Table A-1 contains descriptive statistics on the occupational employment of DBCs. The biotechnology areas of molecular genetics (9.6 percent of DBC Ph.D. employment), general microbiology (7.0 percent), human/animal molecular biology (8.8 percent), immunology (6.1 percent), general biochemistry (14.1 percent), and other chemistry (18.3 percent) are the largest occupational groups. All other Ph.D. scientist occupations combined totaled 36.6 percent of DBC Ph.D. employment.

**Shortage Occupations**: Table A-1 also contains estimates of shortages by occupation. A shortage was defined in the survey as "a vacancy that went unfilled for 90 days or longer, even though you actively sought to fill it." Overall, 5.5 percent of total DBC employment was classified as "shortages." Biotechnology specialties with "large" shortages (defined as 9 percent or more of current employment) included industrial microbiology (9.8 percent), human/animal molecular biology (9.7 percent), pharmacology (11.9 percent), toxicology (17.8 percent), and enzymology (11.9 percent). In terms of total shortages, biochemistry and general chemistry had the most absolute vacancies with 42 and 45, respectively. These findings are somewhat different from those of OTA in its 1987 report. In that report companies reported an ample supply of scientists trained in molecular biology, biochemistry, cell biology, and immunology.[5]

**Planned Hires**: The DBCs surveyed were asked to estimate the number of Ph.D. scientists that they planned to hire in the 1988-1989 period. These planned hires were for both replacements and new hires. Firms traditionally have been optimistic in estimating future planned growth; however, the planned hires variable does give one an idea of the relative growth among occupations.[6]

Table A-1 contains planned hires as a percent of total employment; this percent thus reflects both growth and replacement. Most of the specialties that are expected to have a high rate of planned hires also are those defined as shortage specialties. Toxicology, industrial microbiology, and other biotechnology specialties all had high rates of planned hires. Overall, the DBCs indicated that they planned to hire 18.8 percent of their current level of scientist employment in 1988-1989. The planned hire rate for engineers is 16.4 percent, which runs counter to recent speculation that the industry is moving away from research (and a rich mix of scientists) toward production (and a rich mix of engineers and technicians). The DBCs surveyed indicated that the most common response to shortages was to increase recruitment efforts (69.8 percent of the firms) and to offer higher salaries (37.4 percent of the firms).

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[4] This compares very favorably with the SDR 1987 survey results that indicated 77.6 percent of Ph.D. biomedical scientists employed by private industry had as a primary work activity R&D or the management of R&D.

[5] Office of Technology Assessment, *New Developments in Biotechnology*, p. 135.

[6] Biotechnology companies reported a 42-percent planned staff increase for the 1983-1984 period; the actual increase was 20 percent. (Office of Technology Assessment, *New Developments in Biotechnology*, p. 133).

## EMPLOYMENT GROWTH

The 1987 OTA report estimates 1987 DBC employment at 24,347 overall, with 13,221 scientists and technicians. Large diversified companies were estimated to have another 11,600 workers overall and 5,360 scientists and technicians.[7] The NAS/NSF survey of DBCs estimated a total 1989 employment of 53,985, with 14,534 scientists and technicians. It is likely that most of the difference between the 1987 OTA and the NAS/NSF surveys is explained by the more comprehensive survey frame: the OTA survey queried 296 firms, and the NAS/NSF survey frame was 512. This difference also may explain a portion of the difference in occupational structure (i.e., the OTA survey estimated 54 percent of total employment composed of scientists and technicians, and the NAS/NSF survey estimated 27 percent). If the NAS/NSF frame included firms that engaged in medical services as well as research (blood and urine testing, for example), they would have a smaller portion of their work force research-oriented. Thus, the wider "net" of the NAS/NSF survey may have caught biotechnology firms outside the core of research firms.

However, it is likely that some portion of the difference in the OTA totals and the NAS/NSF totals was due to growth. Planned scientist hires for 1988-1989 because of growth were estimated by the DBCs at 8.7 percent, which is close to the historical rate of private sector growth of Ph.D. biomedical scientist employment of 9.1 percent experienced from 1973-1987. Of firms with scientist job vacancies, 29.2 percent reported more vacancies than the previous year, 45.6 percent reported the same level of scientist vacancies, and 25.2 reported fewer vacancies.

## FIRM PERCEPTIONS

In addition to the quantitative data, the NAS/NSF survey selected 40 firms that had large segments of biomedical/behavioral scientist employment for a special follow-up telephone survey. The supervisors of the biomedical and behavioral research scientist work force in these firms were contacted and asked to discuss the two areas summarized below.

1. *How well has the traditional training of scientists prepared them for their careers in industry?* In general, the telephone respondents were very pleased with the quality of academic training that their scientists received. The major complaint that was expressed with newly trained scientists is that they do not have a goal-oriented (or product-oriented) approach to their research. Industrial research requires more "focus" than academic research. Even basic research in industry requires timetables and goals. A second complaint mentioned by several of the telephone respondents was a lack of both oral and written communication skills.

2. *What is the value of postdoctoral training for industrial research scientists?* Almost without exception, the telephone respondents felt that the postdoctoral experience was a very important "seasoning" process for their scientists. Firms actively sought out postdoctorates for hiring, and they were more than willing to pay a salary premium for scientists with postdoctoral experience.

In view of the comments in question 1 above, it appears that the postdoctorate works as a screening mechanism that allows a newly minted Ph.D. to prove his/her ability for independent research. A postdoctoral appointment in industry as opposed to an academic setting is preferred.

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[7] See Office of Technology Assessment, *New Developments in Biotechnology*, Table 8-1.

## DATA NEEDS FOR PROGRAM EVALUATION

To assess the numerical adequacy of the nation's biomedical and behavioral research personnel and to make judgments about the quality of their training, we need both quantitative and qualitative information. Timely, accurate, and relevant information is essential to the success of this effort. A number of data sets are maintained by NIH and other federal agencies that are directly relevant to the responsibilities of the Committee on Biomedical and Behavioral Research Personnel. Unfortunately, some of the sets are complex and difficult to manipulate. Even when one manages to retrieve information from them, the information's quality is sometimes questionable. We propose to extract from them and from other sources a data set that is tailored to the information needs of this committee and potentially to those of NIH.

The proposed "evaluation data matrix" could form the core of a management information system for use in tracking and evaluating the National Research Service Award (NRSA) program. The difficulties encountered by this committee in simply attempting to correlate the historical levels of prior committee recommendations with actual NRSA awards by field suggest that this tracking has been difficult at best. What is needed is a coordinated systematic data set that provides descriptive and comparative statistics relevant to the committee. It should be coordinated and systematic in its use of common taxonomies and measures that satisfy the needs of the committee. It should be descriptive of programs at a level of detail that the committee deems appropriate, providing information about characteristics, both of the programs and of their participants, and it should be comparative across programs and through time.

The needed data set can be conceptualized simply as a time series of matrices whose rows represent program categories (or "activity codes," as they are called by NIH) such as F31: predoctoral individual NRSA fellowship. The columns represent characteristics of the programs and their participants. For example, one of the nine program characteristics requested was median length of training time. Thus, a cell in this column would represent the median training time of the program type that the particular row represents. Primarily for the benefit of future versions of our committee, we have undertaken an initial design and pilot construction of such a data matrix. Our design of both rows and columns is shown below.

In order to gain an idea of the magnitude and feasibility of the project, we contracted with a firm that is experienced in working with the relevant data bases to undertake a pilot construction.

**Results**: The contracted firm concluded that, while some items of the data matrix could be constructed fairly readily, others would involve a greater level of effort to construct. In principle, at least, data exist with which to construct all cells of the 39 by 20 matrix. The exercise revealed several important problems, most of which the committee had been aware. The five most important problems with the existing data sets are described briefly in the following section.

**Problems in the Data Sets**: The data sets are subject to a number of criticisms, five of which are most serious for our purposes.

1. *Access*: Since our study was located in NAS/NRC's Office of Scientific and Engineering Personnel (OSEP), which also houses the Survey of Earned Doctorates (SED) and SDR, there was no problem in accessing these data. However, there are some difficulties in accessing the major NIH data sets. Although our staff have direct accessing abilities, it appears preferable to work through the NIH staff. The Information for Management, Planning, Analysis and Coordination (IMPAC) file is the primary source of financial

and other data on Public Health Service (PHS) extramural programs; data are organized by fiscal year. The Information Systems Branch of the Division of Research Grants (DRG) responds to requests for data regarding these PHS activities. In addition, DRG provides annual data that are used by the National Research Council (NRC) to update the Trainee Fellow File (TFF) and Consolidated Grant Applicant File (CGAF). These two files are organized by individual recipients of traineeships, fellowships, or grants. Data derived by DRG from the IMPAC file are considered to be "official" data, while data derived by others from TFF and CGAF may be considered for some purposes to be "unofficial." A written request for data to be extracted from the IMPAC file was sent on behalf of the committee to DRG. Some materials were received from DRG, although most were not at the level of detail needed for the data matrix. Some unofficial data were extracted by the contracted firm from the TFF and CGAF files and provided to the committee, forming the basis of the statistical profile of training programs in Chapter 2.

2. *Quality of CGAF and TFF files*: These two files rearrange the IMPAC information to identify all the training received by a single individual (TFF) and all the research grants given to an individual principal investigator (CGAF). This information is essential for the committee to determine the subsequent research participation of those who have received NRSA research training and to do longitudinal studies of participation in NRSA research. Some concerns have been expressed by DRG and NIH about the quality of these two data sets. Thus, we recommend that NIH evaluate the accuracy of a sample of the data sets.

3. *Classification of race/ethnicity and sex*: Apparently there are problems of nonreporting and incorrect reporting of gender and race/ethnicity data on the IMPAC file. A representative of DRG discourages the use of these data. This is most discouraging in light of the clear need to monitor progress of women and minorities in science. We recommend further investigation of data quality, including the matching of individuals across sources of data and over time in an effort to resolve inconsistent reporting of data.

4. *Classification of training field*: The definition of fields of science presents several problems. The Discipline/Specialty/Field (D/S/F) codes in the IMPAC file apparently have not been coded consistently across the various institutes of NIH and ADAMHA. The DRF, derived from the SED, provides data only for Ph.D.s and does not take into account persons with degrees in one field who are receiving additional training in another. The D/S/F codes need additional investigating; it may be the case that they provide sufficiently accurate data at the broad field levels of biomedical sciences and behavioral sciences, but we cannot be certain without further investigation. We strongly recommend that NIH investigate the accuracy of this classification and, if necessary, design better centralized quality control methods and apply them to these classifications.

5. *Response rates in the SDR*: These rates have been extremely low for many years, varying across fields from the high 40s to the low 70s. We recognize the complexities and problems of attrition in a longitudinal data set such as this but recommend that ways be found to improve the rates. An NAS panel on the NSF data system, of which the SDR is a part, recently has made a

similar recommendation.[8] We understand that a study of nonresponse bias in the SDR currently is under way within NAS/NRC and await its results with interest.

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[8] C. F. Citro and G. Kolton (eds.), *Surveying the Nation's Scientists and Engineers: a Data System for the 1990s*, Washington, D.C.: National Academy Press, 1989.

## Preliminary List of Evaluation Data Matrix
## Rows: Program Categories

1. Basic Biomedical Science
   a. Predoctoral
      - o Individual
        - oo NRSA Fellowships
        - oo Other
      - o Institutional
        - oo MARC Undergraduate
        - oo NRSA Traineeships
        - oo Other
   b. Postdoctoral
      - o Individual
        - oo NRSA Fellowships
        - oo Career Development Awards (K07, K08)
        - oo Other
      - o Institutional
        - oo NRSA Traineeships
        - oo Other

2. Behavioral Sciences
   a. Predoctoral
      - o Individual
        - oo NRSA Fellowships
        - oo Other
      - o Institutional
        - oo MARC Undergraduate
        - oo NRSA Traineeships
        - oo Other
   b. Postdoctoral
      - o Individual
        - oo NRSA Fellowships
        - oo Career Development Awards (K07, K08)
        - oo Other
      - o Institutional
        - oo NRSA Traineeships
        - oo Other

3. Clinical Sciences
   a. Predoctoral
      - o Individual
        - oo NRSA Fellowships
        - oo Other
      - o Institutional
        - oo NRSA Traineeships
        - oo Other
   b. Postdoctoral
      - o Individual
        - oo NRSA Fellowships
        - oo Career Development Awards (KXX series, including K11, K15)
        - oo Other
      - o Institutional
        - oo NRSA Traineeships
        - oo Other

## PRELIMINARY LIST OF MATRIX COLUMNS: CHARACTERISTICS OF PROGRAMS AND PARTICIPANTS

1. Program characteristics in given year

    a. Goals
    b. Number of institutions involved
    c. Number of recipients
    d. Median length of training
    e. Total enrollment
    f. Total cost
    g. Cost per recipient month
    h. Median number of trainees per institution
    i. Publication counts of faculty in primary department(s) of program

2. Participant characteristics in given year (median, except as noted)

    a. Baccalaureate selectivity scores (A. Astin)
    b. Quality rating (NRC, 1982) of doctoral department
    c. Quality rating of primary department in postdoctoral programs
    d. GRE scores
    e. Percent female
    f. Percent Asian/Pacific Islander
    g. Percent other minority
    h. Number of publications in first K postdoctoral years
    i. Number of citations in first K postdoctoral years
    j. Percent who apply for research grants in first K post-doctoral years
    k. Percent who receive research grants in first K post-doctoral years
    l. Percent in academia K years after termination of training

# SUMMARY OF EMPLOYMENT TRENDS

Table A-1. Occupational Employment in Dedicated Biotechnology Companies, 1989

| Occupation | Total Employed | Total Employed Ph.D.s | Shortage as % of Employed | Planned Hires as % of Employed |
|---|---|---|---|---|
| BIOTECHNOLOGY SPECIALTIES | | | | |
| Molecular Genetics | 724 | 340 | 2.7% | 13.8% |
| Classical Genetics | 42 | 20 | 5.1% | 15.3% |
| Industrial Microbiology | 311 | 72 | 9.8% | 29.3% |
| General Microbiology | 665 | 248 | 1.2% | 10.1% |
| Human/Animal Cell Biology | 471 | 198 | 3.0% | 10.1% |
| Plant Cell Biology | 86 | 45 | 4.5% | 13.4% |
| Human/Animal Molecular Biology | 508 | 309 | 9.7% | 21.7% |
| Plant Molecular Biology | 90 | 55 | 3.7% | 11.0% |
| Human/Animal Biology | 246 | 87 | 3.4% | 11.5% |
| Plant Biology | 42 | 25 | 4.0% | 15.8% |
| Pharmacology | 209 | 93 | 11.9% | 25.9% |
| Toxicology | 73 | 17 | 17.8% | 29.7% |
| Enzymology | 81 | 59 | 11.9% | 27.2% |
| Immunology | 532 | 216 | 7.9% | 20.8% |
| other biology | 154 | 39 | 2.5% | 15.3% |
| Analytical Biochemistry | 377 | 156 | 3.9% | 20.5% |
| General Biochemistry | 1042 | 498 | 6.0% | 17.7% |
| Other Chemistry | 1397 | 644 | 5.0% | 21.7% |
| Other Biotechnology Specialties | 369 | 163 | 3.7% | 43.0% |
| TOTAL | 7420 | 3282 | 5.4% | 19.4% |
| OTHER SCIENTISTS | | | | |
| Medical Science, MD | 66 | 0 | 0.0% | 0.0% |
| Medical Science, non MD | 104 | 18 | 0.0% | 65.8% |
| Health Physics | 3 | 0 | 0.0% | 0.0% |
| Agricultural Sciences | 73 | 27 | 3.8% | 3.8% |
| Other Physical Sciences | 191 | 43 | 11.5% | 16.1% |
| Behavioral/Social Sciences | 310 | 67 | 3.0% | 3.0% |
| Computer Sciences | 655 | 59 | 1.7% | 1.7% |
| Mathematics | 115 | 31 | 22.7% | 16.2% |
| TOTAL | 1517 | 246 | 6.5% | 11.4% |
| TOTAL SCIENTISTS | 8937 | 3527 | 5.5% | 18.8% |
| ENGINEERS | | | | |
| Biochemical Engineer | 170 | 0 | 9.1% | 30.6% |
| Bioengineer | 279 | 0 | 14.6% | 25.6% |
| Bioprocess Engineer | 115 | 0 | 3.7% | 50.0% |
| Other Engineers | 2337 | 0 | 2.0% | 12.4% |
| TOTAL ENGINEERS | 2901 | 0 | 3.7% | 16.4% |
| TOTAL TECHNICIANS | 5597 | 0 | 3.6% | 19.4% |
| OTHER EMPLOYMENT | 36550 | | | |
| TOTAL EMPLOYMENT | 53985 | | | |

NOTE: Shortages and new hires for engineers and technicians are computed on total employment; for scientists the base is Ph.D. employment. Shortages are defined as unfilled vacancies for 90 days or longer.

SOURCE: NSF Survey of Dedicated Biotechnology Companies, 1989.

Table A-2. Total and R&D Employment by Employment Sector, 1973-1987, Biomedical Scientists

| Year | Total | Academic | Postdoc | Labs | Govn | Indus | Self-Empl | Hosp | Non-profit | Other |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | | | | |
| 1973 | 43244 | 25471 | 3607 | 1031 | 4338 | 5369 | 518 | 1431 | 1293 | 186 |
| 1975 | 50088 | 28332 | 5369 | 994 | 4517 | 6662 | 840 | 1948 | 1232 | 194 |
| 1977 | 54234 | 30384 | 6312 | 1040 | 4568 | 6893 | 862 | 2297 | 1543 | 335 |
| 1979 | 61649 | 33566 | 7268 | 1079 | 5080 | 8455 | 1178 | 2726 | 1858 | 439 |
| 1981 | 68039 | 36482 | 8026 | 1236 | 5398 | 9928 | 1857 | 2799 | 2088 | 225 |
| 1983 | 70471 | 36963 | 7827 | 661 | 5988 | 11819 | 1910 | 2946 | 2102 | 255 |
| 1985 | 78687 | 41032 | 8364 | 783 | 6479 | 13706 | 2254 | 3307 | 2460 | 302 |
| 1987 | 84434 | 43025 | 8172 | 909 | 7049 | 15928 | 2634 | 3629 | 2651 | 437 |
| Growth | 4.9% | 3.8% | 6.0% | -0.9% | 3.5% | 8.1% | 12.3% | 6.9% | 5.3% | 6.3% |
| R&D | | | | | | | | | | |
| 1973 | 23188 | 9915 | 3403 | 926 | 3094 | 4110 | 20 | 648 | 1013 | 58 |
| 1975 | 25955 | 10292 | 4776 | 933 | 3107 | 4949 | 53 | 861 | 954 | 32 |
| 1977 | 29378 | 12523 | 5590 | 977 | 2936 | 5084 | 45 | 1035 | 1146 | 42 |
| 1979 | 34554 | 15015 | 6103 | 916 | 3321 | 6247 | 110 | 1383 | 1404 | 56 |
| 1981 | 38807 | 16628 | 7183 | 1130 | 3529 | 7196 | 126 | 1272 | 1723 | 20 |
| 1983 | 39034 | 16910 | 6828 | 621 | 3608 | 8283 | 207 | 1031 | 1529 | 17 |
| 1985 | 43595 | 19607 | 6924 | 698 | 3818 | 9382 | 283 | 1092 | 1780 | 11 |
| 1987 | 51110 | 22751 | 7346 | 746 | 4670 | 12359 | 328 | 1143 | 1749 | 19 |
| Growth | 5.8% | 6.1% | 5.6% | -1.5% | 3.0% | 8.2% | 22.1% | 4.1% | 4.0% | -7.6% |
| Percent R&D | | | | | | | | | | |
| 1973 | 53.6% | 38.9% | 94.4% | 89.8% | 71.3% | 76.5% | 3.9% | 45.3% | 78.4% | 30.9% |
| 1975 | 51.8% | 36.3% | 88.9% | 93.8% | 68.8% | 74.3% | 6.3% | 44.2% | 77.4% | 16.5% |
| 1977 | 54.2% | 41.2% | 88.6% | 93.9% | 64.3% | 73.8% | 5.2% | 45.0% | 74.3% | 12.6% |
| 1979 | 56.0% | 44.7% | 84.0% | 84.9% | 65.4% | 73.9% | 9.3% | 50.7% | 75.5% | 12.7% |
| 1981 | 57.0% | 45.6% | 89.5% | 91.4% | 65.4% | 72.5% | 6.8% | 45.4% | 82.5% | 8.9% |
| 1983 | 55.4% | 45.7% | 87.2% | 93.9% | 60.3% | 70.1% | 10.8% | 35.0% | 72.7% | 6.7% |
| 1985 | 55.4% | 47.8% | 82.8% | 89.1% | 58.9% | 68.4% | 12.6% | 33.0% | 72.4% | 3.7% |
| 1987 | 60.5% | 52.9% | 89.9% | 82.1% | 66.2% | 77.6% | 12.5% | 31.5% | 66.0% | 4.4% |

SOURCE: 1973-1987 Survey of Doctorate Recipients.

Table A-3. Total and R&D Employment by Employment Sector, 1973-1987, Nonclinical Psychologists

| Year | Total | Academic | Postdoc | Labs | Govn | Indus | Self-Empl | Hosp | Nonprofit | Other |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | | | | |
| 1973 | 13159 | 9452 | 259 | 0 | 1083 | 999 | 323 | 269 | 562 | 212 |
| 1975 | 15209 | 10863 | 398 | 0 | 1170 | 1218 | 401 | 470 | 560 | 129 |
| 1977 | 15711 | 10905 | 394 | 0 | 1404 | 1344 | 443 | 447 | 519 | 255 |
| 1979 | 16314 | 11538 | 527 | 0 | 1164 | 1355 | 321 | 401 | 574 | 434 |
| 1981 | 18496 | 12586 | 511 | 0 | 1235 | 1826 | 905 | 507 | 631 | 295 |
| 1983 | 19025 | 12404 | 302 | 0 | 1320 | 2258 | 1328 | 629 | 451 | 333 |
| 1985 | 19694 | 13221 | 593 | 0 | 1189 | 1924 | 1270 | 585 | 667 | 245 |
| 1987 | 20510 | 13058 | 666 | 0 | 1724 | 1745 | 1655 | 555 | 858 | 249 |
| Growth | 3.2% | 2.3% | 7.0% | | 3.4% | 4.1% | 12.4% | 5.3% | 3.1% | 1.2% |
| R&D | | | | | | | | | | |
| 1973 | 4127 | 2072 | 251 | 0 | 657 | 464 | 47 | 119 | 416 | 101 |
| 1975 | 4310 | 1847 | 364 | 0 | 825 | 584 | 51 | 209 | 392 | 38 |
| 1977 | 4656 | 2106 | 348 | 0 | 909 | 740 | 16 | 188 | 297 | 52 |
| 1979 | 5383 | 2809 | 442 | 0 | 830 | 694 | 32 | 160 | 339 | 77 |
| 1981 | 5390 | 2750 | 369 | 0 | 748 | 838 | 128 | 162 | 396 | 0 |
| 1983 | 5028 | 2619 | 262 | 0 | 650 | 890 | 215 | 146 | 216 | 29 |
| 1985 | 5040 | 2566 | 356 | 0 | 678 | 897 | 157 | 125 | 224 | 37 |
| 1987 | 6135 | 3086 | 561 | 0 | 1013 | 752 | 137 | 105 | 412 | 69 |
| Growth | 2.9% | 2.9% | 5.9% | | 3.1% | 3.5% | 8.0% | -0.9% | -0.1% | -2.6% |
| Percent R&D | | | | | | | | | | |
| 1973 | 31.4% | 21.9% | 96.9% | 0.0% | 60.7% | 46.4% | 14.5% | 44.3% | 74.0% | 47.5% |
| 1975 | 28.3% | 17.0% | 91.4% | 0.0% | 70.5% | 48.0% | 12.7% | 44.5% | 70.0% | 29.7% |
| 1977 | 29.6% | 19.3% | 88.3% | 0.0% | 64.7% | 55.1% | 3.6% | 42.1% | 57.1% | 20.6% |
| 1979 | 33.0% | 24.3% | 84.0% | 0.0% | 71.3% | 51.2% | 10.0% | 40.0% | 59.1% | 17.7% |
| 1981 | 29.1% | 21.9% | 72.2% | 0.0% | 60.5% | 45.9% | 14.1% | 31.9% | 62.8% | 0.0% |
| 1983 | 26.4% | 21.1% | 86.7% | 0.0% | 49.3% | 39.4% | 16.2% | 23.2% | 48.0% | 8.7% |
| 1985 | 25.6% | 19.4% | 60.0% | 0.0% | 57.0% | 46.6% | 12.3% | 21.4% | 33.6% | 15.0% |
| 1987 | 29.9% | 23.6% | 84.2% | 0.0% | 58.7% | 43.1% | 8.3% | 19.0% | 48.0% | 27.8% |

SOURCE: 1973-1987 Survey of Doctorate Recipients.

Table A-4. Total and R&D Employment by Employment Sector, 1973-1987, Other Behavioral Sciences

| Year | Total | Aca-demic | Post-doc | Labs | Govn | Indus | Self-Empl | Hosp | Non-profit | Other |
|---|---|---|---|---|---|---|---|---|---|---|
| Total | | | | | | | | | | |
| 1973 | 6689 | 6135 | 98 | 0 | 121 | 42 | 52 | 12 | 187 | 42 |
| 1975 | 8351 | 7621 | 151 | 0 | 210 | 21 | 55 | 41 | 238 | 14 |
| 1977 | 10322 | 9239 | 246 | 0 | 311 | 40 | 81 | 46 | 306 | 53 |
| 1979 | 11127 | 9568 | 282 | 0 | 453 | 129 | 103 | 54 | 497 | 41 |
| 1981 | 11019 | 9477 | 199 | 0 | 463 | 57 | 183 | 37 | 457 | 146 |
| 1983 | 12749 | 11002 | 271 | 0 | 385 | 128 | 380 | 218 | 249 | 116 |
| 1985 | 12945 | 11009 | 256 | 0 | 218 | 193 | 466 | 373 | 304 | 126 |
| 1987 | 12928 | 10767 | 192 | 0 | 379 | 229 | 455 | 408 | 346 | 152 |
| Growth | 4.8% | 4.1% | 4.9% | | 8.5% | 12.9% | 16.8% | 28.6% | 4.5% | 9.6% |
| R&D | | | | | | | | | | |
| 1973 | 1309 | 934 | 98 | 0 | 81 | 20 | 28 | 12 | 125 | 11 |
| 1975 | 1557 | 1062 | 116 | 0 | 150 | 9 | 12 | 15 | 188 | 4 |
| 1977 | 2171 | 1455 | 206 | 0 | 193 | 20 | 23 | 14 | 251 | 9 |
| 1979 | 2680 | 1653 | 200 | 0 | 297 | 81 | 14 | 10 | 411 | 15 |
| 1981 | 2333 | 1403 | 111 | 0 | 428 | 12 | 4 | 11 | 336 | 28 |
| 1983 | 2065 | 1456 | 161 | 0 | 179 | 2 | 45 | 9 | 151 | 62 |
| 1985 | 1967 | 1479 | 115 | 0 | 126 | 21 | 52 | 47 | 113 | 12 |
| 1987 | 2539 | 1688 | 136 | 0 | 232 | 147 | 78 | 74 | 177 | 8 |
| Growth | 4.8% | 4.3% | 2.4% | | 7.8% | 15.3% | 7.7% | 13.9% | 2.5% | -2.2% |
| Percent R&D | | | | | | | | | | |
| 1973 | 19.6% | 15.2% | 100.0% | 0.0% | 67.3% | 47.6% | 53.3% | 100.0% | 66.9% | 25.7% |
| 1975 | 18.6% | 13.9% | 77.0% | 0.0% | 71.6% | 42.9% | 22.6% | 35.7% | 79.0% | 28.6% |
| 1977 | 21.0% | 15.8% | 83.9% | 0.0% | 61.9% | 50.0% | 28.4% | 30.4% | 82.0% | 16.7% |
| 1979 | 24.1% | 17.3% | 71.1% | 0.0% | 65.5% | 62.7% | 13.6% | 18.5% | 82.7% | 35.6% |
| 1981 | 21.2% | 14.8% | 55.9% | 0.0% | 92.4% | 21.1% | 2.2% | 29.7% | 73.5% | 18.9% |
| 1983 | 16.2% | 13.2% | 59.3% | 0.0% | 46.5% | 1.7% | 12.0% | 4.0% | 60.5% | 53.2% |
| 1985 | 15.2% | 13.4% | 44.9% | 0.0% | 57.9% | 11.0% | 11.1% | 12.7% | 37.3% | 9.9% |
| 1987 | 19.6% | 15.7% | 70.8% | 0.0% | 61.1% | 64.0% | 17.1% | 18.2% | 51.1% | 5.2% |

SOURCE: 1973-1987 Survey of Doctorate Recipients.

Table A-5. Educational Achievements, 1975-1988, by Race (Numbers in Thousands)

| | Black | Percent Loss | White | Percent Loss |
|---|---|---|---|---|
| 18-year-olds, 1975[1] | 559 | | 3,684 | |
| H.S. Dropouts aged 18 in 1975[2] | 142 | 25.4 | 542 | 14.7 |
| H.S. Graduates, 1975 | 417 | | 3,142 | |
| Freshmen, 1975[3] | 80 | 80.8 | 1,065 | 66.1 |
| Baccalaureates, 1979[4] | 60 | 25.0 | 803 | 24.6 |
| Ph.D.s, 1988[5] | 0.81 | 98.7 | 23 | 97.1 |

SOURCES: (1) American Council on Education (ACE), 1981-81 Fact Book for Academic Administrators, Washington, D.C.: ACE, 1981, Table 5.

(2) National Center for Educational Statistics (NCES), Digest of Educational Statistics of Educational Statistics, 1988, NCES, Washington, D.C.: 1988, Table 80.

(3) ACE, op. cit., estimated from Tables 95 and 136.

(4) NCES, op. cit., Table 182.

(5) NAS/NRC, Doctorate Record File.

Table A-6. Estimates of Losses at Selected Points in the Academic Pipelines into Biomedical and Behavioral Science

| | Numbers | | Percent Loss | |
|---|---|---|---|---|
| | Biomedical | Behavioral | Biomedical | Behavioral |
| 1980 Freshmen | 97100 | 172600 | | |
| 1984 B.A./B.S. | 37100 | 58600 | 61.8 | 66.0 |
| 1977-1979 1st Yr. Graduates | 8451 | 9477 | 77.2 | 83.8 |
| 1985-1987 Ph.D.s | 3970 | 4000 | 57.8 | 64.6 |

SOURCES: 1980 freshmen from Astin, A.W. et al., The American Freshman: National Norms for Fall, 1980, Los Angeles: Higher Education Research Institute, University of California at Los Angeles, 1980). All other sources are from Volume II of this report, Summary Tables 2 and 3.

Table A-7. NIH Trainees/Fellows By Years Since Initiation of NRSA Research Training, R01 Grant Activity and Degree Type

| Years Since Init. of NRSA Research Training | | R01 Grant Applicants and Recipients | | | |
|---|---|---|---|---|---|
| | | Applicants | | Recipients | |
| | Total | Number | Percent | Number | Percent |
| M.D. Postdoctoral Fellows: | | | | | |
| 10 | 139 | 81 | 58.3% | 45 | 32.4% |
| 9 | 138 | 69 | 50.0% | 43 | 31.2% |
| 8 | 129 | 56 | 43.4% | 34 | 26.4% |
| 7 | 153 | 61 | 39.9% | 27 | 17.6% |
| 6 | 131 | 45 | 34.4% | 26 | 19.8% |
| 5 | 120 | 34 | 28.3% | 15 | 12.5% |
| Ph.D. Postdoctoral Fellows: | | | | | |
| 10 | 779 | 424 | 54.4% | 291 | 37.4% |
| 9 | 669 | 339 | 50.7% | 231 | 34.5% |
| 8 | 773 | 395 | 51.1% | 251 | 32.5% |
| 7 | 764 | 325 | 42.5% | 199 | 26.0% |
| 6 | 669 | 243 | 36.3% | 144 | 21.5% |
| 5 | 505 | 144 | 28.5% | 82 | 16.2% |
| M.D. Postdoctoral Trainees: | | | | | |
| 10 | 451 | 150 | 33.3% | 94 | 20.8% |
| 9 | 658 | 181 | 27.5% | 91 | 13.8% |
| 8 | 793 | 189 | 23.8% | 90 | 11.3% |
| 7 | 884 | 158 | 17.9% | 87 | 9.8% |
| 6 | 865 | 124 | 14.3% | 62 | 7.2% |
| 5 | 909 | 77 | 8.5% | 34 | 3.7% |
| Ph.D. Postdoctoral Trainees: | | | | | |
| 10 | 742 | 320 | 43.1% | 201 | 27.1% |
| 9 | 909 | 404 | 44.4% | 223 | 24.5% |
| 8 | 1086 | 398 | 36.6% | 207 | 19.1% |
| 7 | 1116 | 354 | 31.7% | 179 | 16.0% |
| 6 | 1044 | 248 | 23.8% | 125 | 12.0% |
| 5 | 1047 | 213 | 20.3% | 108 | 10.3% |

SOURCE: Quantum Research Corporation.

Table A-8. Historical and Projected Job Openings and Ph.D. Supply in the Biomedical Sciences, 1973-1995

| Year | Employment | Death and Retirement | Net Mobility | Growth | Total Openings | PhD Output | Vacancy Ratio | Refreshment Rate | Attrition Rate |
|---|---|---|---|---|---|---|---|---|---|
| Historical | | | | | | | | | |
| 1973 | 39637 | | | | | | | | |
| 1974 | 42101 | 645 | 396 | 2464 | 3506 | 3417 | 1.03 | 0.086 | 0.026 |
| 1975 | 44719 | 691 | 421 | 2618 | 3730 | 3515 | 1.06 | 0.083 | 0.026 |
| 1976 | 46293 | 740 | 447 | 1574 | 2761 | 3578 | 0.77 | 0.080 | 0.027 |
| 1977 | 47922 | 773 | 463 | 1629 | 2865 | 3465 | 0.83 | 0.075 | 0.027 |
| 1978 | 51049 | 806 | 479 | 3127 | 4413 | 3518 | 1.25 | 0.073 | 0.027 |
| 1979 | 54381 | 866 | 510 | 3332 | 4708 | 3644 | 1.29 | 0.071 | 0.027 |
| 1980 | 57128 | 930 | 544 | 2747 | 4220 | 3823 | 1.10 | 0.070 | 0.027 |
| 1981 | 60013 | 985 | 571 | 2885 | 4441 | 3846 | 1.15 | 0.067 | 0.027 |
| 1982 | 61314 | 1043 | 600 | 1301 | 2944 | 3960 | 0.74 | 0.066 | 0.027 |
| 1983 | 62644 | 1074 | 613 | 1330 | 3017 | 3788 | 0.80 | 0.062 | 0.028 |
| 1984 | 66373 | 1106 | 626 | 3729 | 5461 | 3902 | 1.40 | 0.062 | 0.028 |
| 1985 | 70323 | 1181 | 664 | 3950 | 5795 | 3787 | 1.53 | 0.057 | 0.028 |
| 1986 | 73232 | 1261 | 703 | 2909 | 4873 | 3864 | 1.26 | 0.055 | 0.028 |
| 1987 | 76262 | 1323 | 732 | 3030 | 5085 | 3969 | 1.28 | 0.054 | 0.028 |
| Projected (Mid-Case Scenario) | | | | | | | | | |
| 1988 | 80240 | 1388 | 763 | 3978 | 6129 | 3969 | 1.54 | 0.052 | 0.028 |
| 1989 | 82330 | 1460 | 802 | 2090 | 4353 | 3969 | 1.10 | 0.049 | 0.028 |
| 1990 | 85870 | 1564 | 823 | 3540 | 5927 | 3969 | 1.49 | 0.048 | 0.029 |
| 1991 | 88880 | 1582 | 859 | 3010 | 5451 | 3969 | 1.37 | 0.046 | 0.028 |
| 1992 | 91990 | 1593 | 889 | 3110 | 5592 | 3969 | 1.41 | 0.045 | 0.028 |
| 1993 | 95360 | 1601 | 920 | 3370 | 5891 | 3969 | 1.48 | 0.043 | 0.027 |
| 1994 | 98720 | 1788 | 954 | 3360 | 6102 | 3969 | 1.54 | 0.042 | 0.029 |
| 1995 | 102460 | 1816 | 987 | 3740 | 6543 | 3969 | 1.65 | 0.040 | 0.028 |

SOURCE: Historical employment data are from Appendix Table A-2; historical Ph.D. data are from Table B3 of Volume II. All other values estimated by NRC.

Table A-9. Historical and Projected Job Openings and Ph.D. Supply in Nonclinical Psychology, 1973-1995

| Year | Employment | Death and Retirement | Net Mobility | Growth | Total Openings | PhD Output | Vacancy Ratio | Refreshment Rate | Attrition Rate |
|---|---|---|---|---|---|---|---|---|---|
| Historical | | | | | | | | | |
| 1973 | 6591 | | | | | 1084 | | | |
| 1974 | 7352 | 94 | 198 | 761 | 1052 | 1152 | 0.91 | 0.175 | 0.044 |
| 1975 | 8200 | 110 | 221 | 848 | 1179 | 1187 | 0.99 | 0.161 | 0.045 |
| 1976 | 9090 | 129 | 246 | 890 | 1265 | 1307 | 0.97 | 0.159 | 0.046 |
| 1977 | 10076 | 150 | 273 | 986 | 1409 | 1256 | 1.12 | 0.138 | 0.047 |
| 1978 | 10453 | 174 | 302 | 377 | 853 | 1152 | 0.74 | 0.114 | 0.047 |
| 1979 | 10845 | 188 | 314 | 392 | 893 | 1154 | 0.77 | 0.110 | 0.048 |
| 1980 | 10832 | 203 | 325 | -13 | 516 | 1094 | 0.47 | 0.101 | 0.049 |
| 1981 | 10820 | 211 | 325 | -12 | 523 | 1114 | 0.47 | 0.103 | 0.049 |
| 1982 | 11619 | 219 | 325 | 799 | 1343 | 1030 | 1.30 | 0.095 | 0.050 |
| 1983 | 12478 | 243 | 349 | 859 | 1451 | 1011 | 1.43 | 0.087 | 0.051 |
| 1984 | 12583 | 271 | 374 | 105 | 750 | 954 | 0.79 | 0.076 | 0.052 |
| 1985 | 12689 | 282 | 377 | 106 | 766 | 913 | 0.84 | 0.073 | 0.052 |
| 1986 | 12712 | 294 | 381 | 23 | 698 | 955 | 0.73 | 0.075 | 0.053 |
| 1987 | 12736 | 304 | 381 | 24 | 709 | 882 | 0.80 | 0.069 | 0.054 |
| Projected (Mid-Case Scenario) | | | | | | | | | |
| 1988 | 12900 | 308 | 395 | 164 | 867 | 882 | 0.98 | 0.069 | 0.055 |
| 1989 | 13070 | 312 | 400 | 170 | 882 | 882 | 1.00 | 0.068 | 0.055 |
| 1990 | 13260 | 303 | 410 | 190 | 903 | 882 | 1.02 | 0.067 | 0.055 |
| 1991 | 13470 | 293 | 394 | 210 | 897 | 882 | 1.02 | 0.067 | 0.052 |
| 1992 | 13700 | 286 | 382 | 230 | 898 | 882 | 1.02 | 0.065 | 0.050 |
| 1993 | 13950 | 283 | 373 | 250 | 906 | 882 | 1.03 | 0.064 | 0.048 |
| 1994 | 14220 | 297 | 389 | 270 | 956 | 882 | 1.08 | 0.063 | 0.049 |
| 1995 | 14510 | 307 | 405 | 290 | 1002 | 882 | 1.14 | 0.062 | 0.050 |

SOURCE: Historical employment data are from Appendix Table A-4; historical Ph.D. data are from Table C10 of Volume II. All other values estimated by NRC.

Table A-10. Historical and Projected Job Openings and Ph.D. Supply in Other Behavioral Sciences, 1973-1995

| Year | Employment | Death and Retirement | Net Mobility | Growth | Total Openings | PhD Output | Vacancy Ratio | Refreshment Rate | Attrition Rate |
|---|---|---|---|---|---|---|---|---|---|
| Historical | | | | | | | | | |
| 1973 | 12900 | | | | | | | | |
| 1974 | 13823 | 184 | 387 | 923 | 1494 | 1537 | 0.97 | 0.119 | 0.044 |
| 1975 | 14811 | 208 | 415 | 988 | 1611 | 1607 | 1.00 | 0.116 | 0.045 |
| 1976 | 15062 | 233 | 444 | 251 | 929 | 1590 | 0.58 | 0.107 | 0.046 |
| 1977 | 15317 | 249 | 452 | 255 | 956 | 1637 | 0.58 | 0.109 | 0.047 |
| 1978 | 15550 | 264 | 460 | 233 | 957 | 1591 | 0.60 | 0.104 | 0.047 |
| 1979 | 15787 | 280 | 467 | 237 | 983 | 1582 | 0.62 | 0.102 | 0.048 |
| 1980 | 16850 | 296 | 474 | 1063 | 1832 | 1517 | 1.21 | 0.096 | 0.049 |
| 1981 | 17985 | 328 | 506 | 1135 | 1968 | 1615 | 1.22 | 0.096 | 0.049 |
| 1982 | 18350 | 363 | 540 | 365 | 1268 | 1477 | 0.86 | 0.082 | 0.050 |
| 1983 | 18723 | 384 | 551 | 373 | 1308 | 1545 | 0.85 | 0.084 | 0.051 |
| 1984 | 18911 | 406 | 562 | 188 | 1156 | 1504 | 0.77 | 0.080 | 0.052 |
| 1985 | 19101 | 424 | 567 | 190 | 1181 | 1393 | 0.85 | 0.074 | 0.052 |
| 1986 | 19469 | 443 | 573 | 368 | 1384 | 1367 | 1.01 | 0.072 | 0.053 |
| 1987 | 19844 | 465 | 584 | 375 | 1425 | 1366 | 1.04 | 0.070 | 0.054 |
| Projected (Mid-Case Scenario) | | | | | | | | | |
| 1988 | 20030 | 470 | 556 | 186 | 1211 | 1366 | 0.89 | 0.069 | 0.052 |
| 1989 | 20220 | 474 | 566 | 190 | 1230 | 1366 | 0.90 | 0.068 | 0.052 |
| 1990 | 20400 | 471 | 634 | 180 | 1285 | 1366 | 0.94 | 0.068 | 0.055 |
| 1991 | 20600 | 455 | 606 | 200 | 1261 | 1366 | 0.92 | 0.067 | 0.052 |
| 1992 | 20790 | 444 | 583 | 190 | 1217 | 1366 | 0.89 | 0.066 | 0.050 |
| 1993 | 21000 | 438 | 564 | 210 | 1212 | 1366 | 0.89 | 0.066 | 0.048 |
| 1994 | 21210 | 460 | 581 | 210 | 1251 | 1366 | 0.92 | 0.065 | 0.050 |
| 1995 | 21420 | 474 | 599 | 210 | 1283 | 1366 | 0.94 | 0.064 | 0.051 |

SOURCE: Historical employment data are from Appendix Table A-3; historical Ph.D. data are from Table C10 of Volume II. All other values estimated by NRC.

Table A-11. Trends in NIH/ADAMHA M.D. Postdoctoral Trainees/Fellows and Full-Time Faculty in Clinical Departments, 1977-1987

| Year | Number of Trainees/ Fellows | Full-Time Clinical Faculty |
|---|---|---|
| 1961 | 2770 | 7201 |
| 1962 | 3871 | 7698 |
| 1963 | 4220 | 8909 |
| 1964 | 4587 | 9474 |
| 1965 | 4921 | 10649 |
| 1966 | 5081 | 11447 |
| 1967 | 4968 | 13420 |
| 1968 | 5189 | 15654 |
| 1969 | 5222 | 15986 |
| 1970 | 5030 | 16806 |
| 1971 | 4572 | 19256 |
| 1972 | 4401 | 21456 |
| 1973 | 4314 | 23884 |
| 1974 | 3543 | 24950 |
| 1975 | 3127 | 26846 |
| 1976 | 2918 | 28603 |
| 1977 | 2203 | 30349 |
| 1978 | 1879 | 32622 |
| 1979 | 1780 | 34057 |
| 1980 | 1906 | 36665 |
| 1981 | 1938 | 37716 |
| 1982 | 2026 | 40148 |
| 1983 | 2108 | 41938 |
| 1984 | 2184 | 43443 |
| 1985 | 2265 | 45007 |
| 1986 | 2162 | 47193 |
| 1987 | NA | 48834 |

SOURCE: Computed from the NIH Trainee and Fellow File (TFF) and the American Association of Medical Colleges Faculty Roster.

Table A-12. Biomedical and behavioral Doctorate Recipients,[1] 1978-1982 and 1983-1987 Reporting NIH as Primary Source of Graduate School Support

| | 1978-1982 | | | 1983-1987 | | |
|---|---|---|---|---|---|---|
| | Total Known | Percent NIH Support | Percent Deviation[2] | Total Known | Percent NIH Support | Percent Deviation[2] |
| | | | Biomedical Doctorate Recipients | | | |
| Men | | | | | | |
| Asian | 539 | 15.58 | -6.84 | 487 | 19.10 | -4.16 |
| Black | 131 | 14.50 | -7.92 | 146 | 13.01 | -10.25 |
| Other | 137 | 13.87 | -8.55 | 170 | 15.29 | -7.97 |
| White | 9770 | 22.37 | -0.05 | 8357 | 23.85 | 0.59 |
| Women | | | | | | |
| Asian | 294 | 18.37 | -4.06 | 352 | 15.91 | -7.35 |
| Black | 112 | 12.50 | -9.92 | 118 | 13.56 | -9.70 |
| Other | 57 | 24.56 | 2.14 | 128 | 21.88 | -1.39 |
| White | 3771 | 24.69 | 2.27 | 4678 | 24.09 | 0.83 |
| Total | 14811 | 22.42 | 4.63[3] | 14436 | 23.26 | 4.23[3] |
| | | | Behavioral Doctorate Recipients | | | |
| Men | | | | | | |
| Asian | 136 | 3.68 | -1.78 | 130 | 5.38 | 2.45 |
| Black | 298 | 6.04 | 0.59 | 241 | 4.15 | 1.22 |
| Other | 262 | 2.67 | -2.78 | 264 | 4.17 | 1.23 |
| White | 9345 | 5.54 | 0.09 | 7336 | 2.41 | -0.52 |
| Women | | | | | | |
| Asian | 138 | 5.07 | -0.38 | 144 | 4.17 | 1.23 |
| Black | 350 | 4.29 | -1.17 | 374 | 4.01 | 1.08 |
| Other | 153 | 4.58 | -0.88 | 286 | 4.90 | 1.96 |
| White | 6829 | 5.54 | 0.08 | 7665 | 3.16 | 0.23 |
| Total | 17511 | 5.45 | 1.04[3] | 16440 | 2.93 | 0.87[3] |

(1) Includes only U.S. citizens and aliens with permanent visas.
(2) Row percent minus total percent.
(3) Standard deviation of the column.

SOURCE: NRC Doctorate Record File.

Table A-13. Biomedical and Behavioral Doctorate Recipients,[1] 1978-1982 and 1983-1987 Reporting Definite Postdoctoral Plans

| | 1978-1982 | | | 1983-1987 | | |
|---|---|---|---|---|---|---|
| | Total Known | Percent Reporting Plans | Percent Deviation[2] | Total Known | Percent Reporting Plans | Percent Deviation[2] |
| **Biomedical Doctorate Recipients** | | | | | | |
| Men | | | | | | |
| Asian | 567 | 88.18 | -1.42 | 540 | 86.67 | -1.79 |
| Black | 146 | 82.19 | -7.41 | 161 | 75.16 | -13.30 |
| Other | 144 | 87.50 | -2.11 | 192 | 91.67 | 2.06 |
| White | 10032 | 90.90 | 1.29 | 8914 | 90.46 | 2.01 |
| Women | | | | | | |
| Asian | 310 | 82.58 | -7.02 | 383 | 80.94 | -7.52 |
| Black | 116 | 83.62 | -5.98 | 122 | 75.41 | -13.05 |
| Other | 60 | 85.00 | -4.61 | 139 | 76.98 | -12.63 |
| White | 3941 | 87.67 | -1.94 | 4980 | 86.59 | -1.87 |
| Total | 15316 | 89.61 | 2.89[3] | 15431 | 88.46 | 6.25[3] |
| **Behavioral Doctorate Recipients** | | | | | | |
| Men | | | | | | |
| Asian | 151 | 72.85 | -8.28 | 145 | 73.10 | -6.11 |
| Black | 344 | 82.27 | 1.14 | 276 | 76.09 | -3.12 |
| Other | 278 | 83.81 | -5.79 | 286 | 78.67 | -10.93 |
| White | 9790 | 83.01 | 1.89 | 7928 | 81.56 | 2.35 |
| Women | | | | | | |
| Asian | 147 | 65.31 | -15.82 | 167 | 67.07 | -12.14 |
| Black | 392 | 82.14 | 1.02 | 410 | 77.32 | -1.89 |
| Other | 168 | 80.36 | -9.25 | 325 | 76.92 | -12.68 |
| White | 7088 | 78.82 | -2.30 | 8187 | 77.60 | -1.61 |
| Total | 18358 | 81.13 | 5.86[3] | 17724 | 79.21 | 5.25[3] |

(1) Includes only U.S. citizens and aliens with permanent visas.
(2) Row percent minus total percent.
(3) Standard deviation of the column.

SOURCE: NRC Doctorate Record File.

Table A-14. Doctoral Biomedical and Behavioral Scientists Aged 35 and Younger, 1977 and 1987, Reporting Current Postdoctoral Study[1]

Doctoral Biomedical Scientists

| | 1977 | | | 1987 | | |
|---|---|---|---|---|---|---|
| | Total Known | Percent Postdoc Study | Percent Deviation[2] | Total Known | Percent Postdoc Study | Percent Deviation[2] |
| Men | | | | | | |
| Asian | 756 | 40.34 | 15.79 | 996 | 19.38 | -11.29 |
| Black | 84 | 34.52 | 9.97 | 129 | 63.57 | 32.89 |
| Other | 148 | 27.70 | 3.15 | 246 | 33.33 | 2.66 |
| White | 12681 | 21.65 | -2.91 | 10029 | 30.26 | -0.41 |
| Women | | | | | | |
| Asian | 334 | 50.30 | 25.74 | 563 | 38.54 | 7.87 |
| Black | 45 | 26.67 | 2.11 | 56 | 25.00 | -5.67 |
| Other | 31 | 16.13 | -8.43 | 100 | 39.00 | 8.33 |
| White | 2955 | 29.71 | 5.16 | 4437 | 31.91 | 1.24 |
| Total | 17034 | 24.56 | 10.07[3] | 16556 | 30.67 | 12.37[3] |

Doctoral Behavioral Scientists

| | 1977 | | | 1987 | | |
|---|---|---|---|---|---|---|
| | Total Known | Percent Postdoc Study | Percent Deviation[2] | Total Known | Percent Postdoc Study | Percent Deviation[2] |
| Men | | | | | | |
| Asian | 85 | 3.53 | -0.87 | 124 | 4.03 | -0.02 |
| Black | 111 | 0.90 | -3.50 | 77 | 18.18 | 14.13 |
| Other | 143 | 22.38 | 17.98 | 167 | 8.98 | 4.93 |
| White | 8649 | 3.98 | -0.42 | 4624 | 4.35 | 0.30 |
| Women | | | | | | |
| Asian | 66 | 9.09 | 4.69 | 108 | 9.26 | 5.21 |
| Black | 96 | 6.25 | 1.85 | 216 | 4.17 | 0.12 |
| Other | 31 | 0.00 | -4.40 | 139 | 6.47 | 2.43 |
| White | 3280 | 4.76 | 0.36 | 4155 | 3.03 | -1.02 |
| Total | 12461 | 4.40 | 6.62[3] | 9610 | 4.05 | 4.65[3] |

(1) Excludes those reporting retired or not reporting.
(2) Row percent minus total percent.
(3) Standard deviation of the column.

SOURCE: NRC Survey of Earned Doctorates.

Table A-15. Doctoral Biomedical and Behavioral Scientists, 1977 and 1987, Reporting Full-time Employment in Science or Engineering[1]

| | 1977 | | | 1987 | | |
|---|---|---|---|---|---|---|
| | Total Known | Percent NIH Support | Percent Deviation[2] | Total Known | Percent NIH Support | Percent Deviation[2] |
| **Biomedical Doctorate Recipients** | | | | | | |
| Men | | | | | | |
| Asian | 2134 | 95.97 | 4.18 | 5371 | 98.42 | 6.16 |
| Black | 484 | 95.04 | 3.25 | 751 | 94.41 | 2.15 |
| Other | 507 | 87.38 | -4.41 | 911 | 96.93 | 4.67 |
| White | 37766 | 94.60 | 2.81 | 54491 | 94.48 | 2.22 |
| Women | | | | | | |
| Asian | 437 | 77.35 | -14.44 | 1407 | 86.14 | -6.12 |
| Black | 115 | 86.09 | -5.70 | 298 | 81.88 | -10.38 |
| Other | 75 | 64.00 | -27.79 | 247 | 85.43 | -6.84 |
| White | 6423 | 75.39 | -16.40 | 13756 | 81.60 | -10.66 |
| Total | 47941 | 91.79 | 10.67[3] | 77232 | 92.26 | 6.43[3] |
| **Behavioral Doctorate Recipients** | | | | | | |
| Men | | | | | | |
| Asian | 427 | 97.89 | 7.68 | 779 | 93.58 | 8.02 |
| Black | 320 | 89.06 | -1.15 | 722 | 91.41 | 5.85 |
| Other | 308 | 93.83 | 3.62 | 841 | 90.61 | 5.05 |
| White | 29798 | 94.55 | 4.34 | 40013 | 91.02 | 5.46 |
| Women | | | | | | |
| Asian | 137 | 88.32 | -1.89 | 405 | 72.10 | -13.46 |
| Black | 215 | 84.65 | -5.56 | 678 | 86.58 | 1.02 |
| Other | 92 | 80.43 | -9.77 | 433 | 75.06 | -10.50 |
| White | 9215 | 76.00 | -14.21 | 20502 | 74.64 | -10.92 |
| Total | 40512 | 90.21 | 6.97[3] | 64373 | 85.56 | 8.32[3] |

(1) Excludes those reporting retired or not reporting.

(2) Row percent minus total percent.

(3) Standard deviation of the column.

SOURCE: NRC Survey of Earned Doctorates.

Table A-16. Death and Retirement Rates

| Biological Age | Retirement Rate | Death Rate |
|---|---|---|
| <30 | 0 | 0.0011 |
| 30-34 | 0 | 0.0017 |
| 35-39 | 0 | 0.0027 |
| 40-44 | 0 | 0.0038 |
| 45-49 | 0 | 0.0063 |
| 50-54 | 0 | 0.0114 |
| 55-59 | 0.0026 | 0.0179 |
| 60-64 | 0.0753 | 0.0271 |
| 65-69 | 0.1714 | 0.0378 |
| >=70 | 1 | 0.05 |

SOURCE: Charlotte V. Kuh and Roy Radner, *Mathematicians in Academia: 1975-2000, A Report to the National Science Foundation,* Washington, D.C.: Conference Board of the Mathematical Sciences, 1980, pp. 84-86.

Table A-17. Estimated Quit Rates for Biomedical Scientists, 1983-1987

| Career Age | (1) Biomed. | (2) Biomed. RD & Mgt.RD | (3) Postdoc Biomed. | (4) Retired | (5) Total PhDs | (6) Total PhDs -Retired | (7) Bio. Sci. per 1000 Sci. | (8) Annual Quits (%) | (9) Annual R&D Quits (%) |
|---|---|---|---|---|---|---|---|---|---|
| <=5 | 31538 | 19695 | 17309 | 139 | 202517 | 202378 | 241 | | |
| 6-10 | 48171 | 29975 | 2419 | 373 | 219649 | 219276 | 231 | -1.79 | -8.18 |
| 11-15 | 49162 | 26230 | 531 | 990 | 216355 | 215365 | 231 | 0.00 | -6.69 |
| 16-20 | 34190 | 16674 | 135 | 2279 | 156309 | 154030 | 223 | -1.38 | -5.06 |
| 21-25 | 18257 | 8406 | 24 | 4041 | 90762 | 86721 | 211 | -2.20 | -4.52 |
| 26-30 | 12726 | 5383 | 36 | 6428 | 66917 | 60489 | 211 | 0.03 | -3.21 |
| 31-35 | 8567 | 3790 | 24 | 13162 | 55630 | 42468 | 202 | -1.67 | 0.10 |
| 36-40 | 2743 | 1095 | 7 | 11772 | 26291 | 14519 | 189 | -2.60 | -6.51 |
| 41+ | 1295 | 495 | 0 | 6507 | 11286 | 4779 | 271 | 15.40 | 13.24 |
| TOTAL | 206649 | 111743 | 20485 | 45691 | 1045716 | 1000025 | | | |
| | | | | | Average annual quit rate | | | -0.8% | |

SOURCE: 1983, 1985 and 1987 Survey of Doctorate Recipients.

Table A-18. Summary Projections in Biomedical Sciences

Biomedical Sensitivity Model

| Model Assumptions | High | Mid | Low |
|---|---|---|---|
| 1. Federal health R&D funding growth | 4.0% | 2.7% | 0.2% |
| 2. Private health R&D funding growth | 13.0% | 9.0% | 5.0% |
| 3. Other health R&D funding growth | 4.0% | 3.0% | 2.0% |
| 4. Grad and undergrad, biomed enrollment | 1.0% | 0.0% | -1.0% |
| 5. "Other" biomed R&D employment growth | 3.5% | 2.5% | 1.5% |
| 6. "Other" biomed non R&D employ. growth | 10.0% | 8.0% | 5.0% |

Projected Employment of Biomedical Scientists, 1973-2000 (in 100s of workers)

| | Low Case | | | Mid Case | | | High Case | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Total | R&D | % R&D | Total | R&D | % R&D | Total | R&D | % R&D |
| 1973 | 396.4 | 197.8 | 49.9% | 396.4 | 197.8 | 49.9% | 396.4 | 197.8 | 49.9% |
| 1975 | 447.2 | 211.8 | 47.4% | 447.2 | 211.8 | 47.4% | 447.2 | 211.8 | 47.4% |
| 1977 | 479.2 | 237.9 | 49.6% | 479.2 | 237.9 | 49.6% | 479.2 | 237.9 | 49.6% |
| 1979 | 543.8 | 284.5 | 52.3% | 543.8 | 284.5 | 52.3% | 543.8 | 284.5 | 52.3% |
| 1981 | 600.1 | 316.2 | 52.7% | 600.1 | 316.2 | 52.7% | 600.1 | 316.2 | 52.7% |
| 1983 | 626.4 | 322.1 | 51.4% | 626.4 | 322.1 | 51.4% | 626.4 | 322.1 | 51.4% |
| 1985 | 703.2 | 366.7 | 52.1% | 703.2 | 366.7 | 52.1% | 703.2 | 366.7 | 52.1% |
| 1987 | 762.6 | 437.6 | 57.4% | 762.6 | 437.6 | 57.4% | 762.6 | 437.6 | 57.4% |
| 1988 | 786.4 | 451.2 | 57.4% | 802.4 | 464.0 | 57.8% | 816.6 | 475.3 | 58.2% |
| 1989 | 791.6 | 459.0 | 58.0% | 823.3 | 484.1 | 58.8% | 851.6 | 506.5 | 59.5% |
| 1990 | 811.1 | 466.8 | 57.6% | 858.7 | 504.2 | 53.7% | 901.7 | 538.1 | 59.7% |
| 1991 | 825.0 | 474.6 | 57.5% | 888.8 | 524.4 | 59.0% | 947.8 | 570.9 | 60.2% |
| 1992 | 839.3 | 482.4 | 57.5% | 919.9 | 545.2 | 59.3% | 996.8 | 605.9 | 60.8% |
| 1993 | 855.2 | 490.4 | 57.3% | 953.6 | 566.9 | 59.4% | 1050.7 | 643.9 | 61.3% |
| 1994 | 869.6 | 498.5 | 57.3% | 987.2 | 589.8 | 59.7% | 1107.5 | 685.7 | 61.9% |
| 1995 | 886.5 | 506.8 | 57.2% | 1024.6 | 614.1 | 59.9% | 1171.5 | 732.1 | 62.5% |
| 1996 | 894.9 | 515.4 | 57.6% | 1055.3 | 640.1 | 60.6% | 1232.7 | 783.7 | 63.6% |
| 1997 | 913.2 | 524.3 | 57.4% | 1097.9 | 668.1 | 60.8% | 1310.3 | 841.4 | 64.2% |
| 1998 | 928.8 | 533.5 | 57.4% | 1140.0 | 698.3 | 61.3% | 1392.5 | 906.0 | 65.1% |
| 1999 | 947.4 | 543.1 | 57.3% | 1187.7 | 731.0 | 61.6% | 1486.0 | 978.4 | 65.8% |
| 2000 | 973.6 | 553.1 | 56.8% | 1245.6 | 766.5 | 61.5% | 1596.4 | 1059.6 | 66.4% |
| Growth Rates: | | | | | | | | | |
| 73-87 | 4.8% | 5.8% | | 4.8% | 5.8% | | 4.8% | 5.8% | |
| 87-91 | 2.0% | 2.0% | | 3.9% | 4.6% | | 5.6% | 6.9% | |
| 87-20 | 1.9% | 1.8% | | 3.8% | 4.4% | | 5.8% | 7.0% | |

NOTE: This table does not include those in postdoctoral training positions or who are unemployed.
SOURCE: Estimated by NRC.

Table A-19. Historical and Projected Vacancy Ratios, 1973-2000, Biomedical Scientists

| | Annual Averages | | | | | |
|---|---|---|---|---|---|---|
| Year | Vacancies | Total PhDs | Ratio | Vacancies | R&D Post-docs | Ratio |
| 1973-78 | 3455 | 3499 | 0.99 | 2344 | 2868 | 0.82 |
| 1978-83 | 3957 | 3763 | 1.05 | 2863 | 3788 | 0.76 |
| 1983-87 | 4846 | 3862 | 1.25 | 4157 | 4072 | 1.02 |
| 1987-95 | | | | | | |
| Low | 4047 | 3662 | 1.11 | 3086 | 3900 | 0.79 |
| Mid | 5955 | 3969 | 1.50 | 4626 | 3900 | 1.19 |
| High | 8063 | 4298 | 1.88 | 6386 | 3900 | 1.64 |

NOTE: Assumes that Ph.D. production changes in proportion to enrollment assumptions and postdoc production remains constant.

SOURCE: Estimated by NRC.

Table A-20. Summary Projections for Nonclinical Psychology Sensitivity Model

| Model Assumptions | High | Mid | Low |
|---|---|---|---|
| 1. Graduate student enrollment | 1.0% | 0.0% | -1.0% |
| 2. Industrial employment growth | 4.0% | 3.0% | 2.0% |

Projected Employment of Nonclinical Psychologists, 1973-2000 (in 100s of workers)

| | Low Case | | | Mid Case | | | High Case | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Total | R&D | % R&D | Total | R&D | % R&D | Total | R&D | % R&D |
| 1973 | 129.0 | 38.8 | 30.0% | 129.0 | 38.8 | 30.0% | 129.0 | 38.8 | 30.0% |
| 1975 | 148.1 | 39.5 | 26.6% | 148.1 | 39.5 | 26.6% | 148.1 | 39.5 | 26.6% |
| 1977 | 153.2 | 43.1 | 28.1% | 153.2 | 43.1 | 28.1% | 153.2 | 43.1 | 28.1% |
| 1979 | 157.9 | 49.4 | 31.3% | 157.9 | 49.4 | 31.3% | 157.9 | 49.4 | 31.3% |
| 1981 | 179.9 | 50.2 | 27.9% | 179.9 | 50.2 | 27.9% | 179.9 | 50.2 | 27.9% |
| 1983 | 187.2 | 47.7 | 25.5% | 187.2 | 47.7 | 25.5% | 187.2 | 47.7 | 25.5% |
| 1985 | 191.0 | 46.8 | 24.5% | 191.0 | 46.8 | 24.5% | 191.0 | 46.8 | 24.5% |
| 1987 | 198.4 | 55.7 | 28.1% | 198.4 | 55.7 | 28.1% | 198.4 | 55.7 | 28.1% |
| 1988 | 200.0 | 54.9 | 27.5% | 200.3 | 55.0 | 27.5% | 200.7 | 55.2 | 27.5% |
| 1989 | 195.5 | 54.0 | 27.6% | 202.2 | 55.5 | 27.4% | 204.9 | 56.1 | 27.4% |
| 1990 | 195.2 | 53.9 | 27.6% | 204.0 | 55.9 | 27.4% | 209.2 | 57.1 | 27.3% |
| 1991 | 194.9 | 53.9 | 27.6% | 206.0 | 56.3 | 27.4% | 213.6 | 58.1 | 27.2% |
| 1992 | 194.8 | 53.8 | 27.6% | 207.9 | 56.8 | 27.3% | 218.2 | 59.2 | 27.1% |
| 1993 | 194.7 | 53.8 | 27.6% | 210.0 | 57.2 | 27.3% | 223.0 | 60.2 | 27.0% |
| 1994 | 194.7 | 53.8 | 27.6% | 212.1 | 57.7 | 27.2% | 227.9 | 61.3 | 26.9% |
| 1995 | 194.8 | 53.7 | 27.6% | 214.2 | 58.2 | 27.2% | 232.9 | 62.5 | 26.8% |
| 1996 | 194.9 | 53.7 | 27.6% | 216.4 | 58.7 | 27.1% | 238.1 | 63.6 | 26.7% |
| 1997 | 195.1 | 53.7 | 27.5% | 218.7 | 59.2 | 27.0% | 243.4 | 64.8 | 26.6% |
| 1998 | 195.4 | 53.8 | 27.5% | 221.0 | 59.7 | 27.0% | 249.0 | 66.1 | 26.5% |
| 1999 | 195.8 | 53.8 | 27.5% | 223.4 | 60.2 | 26.9% | 254.7 | 67.4 | 26.5% |
| 2000 | 199.2 | 54.5 | 27.3% | 225.9 | 60.7 | 26.9% | 260.6 | 68.7 | 26.4% |
| Growth Rates: | | | | | | | | | |
| 73-87 | 3.1% | 2.6% | | 3.1% | 2.6% | | 3.1% | 2.6% | |
| 87-91 | -0.4% | -0.9% | | 0.9% | 0.3% | | 1.9% | 1.0% | |
| 87-20 | 0.0% | -0.2% | | 1.0% | 0.7% | | 2.1% | 1.6% | |

NOTE: This table does not include postdoctoral employment or unemployment.
SOURCE: Estimated by NRC.

Table A-21. Historical and Projected Vacancy Ratios, 1973-2000, Nonclinical Psychologists

| | Annual Averages | | | | | |
|---|---|---|---|---|---|---|
| | Total | | | R&D | | |
| Year | Vacancies | PhDs | Ratio | Vacancies | Post-docs | Ratio |
| 1973-78 | 1189 | 1592 | 0.75 | 385 | 196 | 1.96 |
| 1978-83 | 1386 | 1555 | 0.89 | 359 | 226 | 1.59 |
| 1983-87 | 1291 | 1435 | 0.90 | 422 | 261 | 1.61 |
| 1990-95 | | | | | | |
| Low | 995 | 1260 | 0.79 | 320 | 300 | 1.07 |
| Mid | 1252 | 1366 | 0.92 | 380 | 300 | 1.27 |
| High | 1551 | 1479 | 1.05 | 449 | 300 | 1.50 |

NOTE: Assumes that Ph.D. production changes in proportion to enrollment assumptions and postdoc production remains constant. Graduate model

SOURCE: Estimated by NRC.

Table A-22. Summary Projections for Other Behavioral Scientists

| Model Assumptions | | High | Mid | Low |
|---|---|---|---|---|
| 1. Graduate student enrollment | | 1.0% | 0.0% | -1.0% |
| 2. "All other" employment growth | | | | |
| | R&D | 7.0% | 5.0% | 3.0% |
| | NonR&D | 15.0% | 10.0% | 7.0% |

Projected Employment of Other Behavioral Scientists, 1973-2000 (in 100s of workers)

| | Low Case | | | Mid Case | | | High Case | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Total | R&D | % R&D | Total | R&D | % R&D | Total | R&D | % R&D |
| 1973 | 65.9 | 12.1 | 18.4% | 65.9 | 12.1 | 18.4% | 65.9 | 12.1 | 18.4% |
| 1975 | 82.0 | 14.4 | 17.6% | 82.0 | 14.4 | 17.6% | 82.0 | 14.4 | 17.6% |
| 1977 | 100.8 | 19.6 | 19.5% | 100.8 | 19.6 | 19.5% | 100.8 | 19.6 | 19.5% |
| 1979 | 108.5 | 24.8 | 22.9% | 108.5 | 24.8 | 22.9% | 108.5 | 24.8 | 22.9% |
| 1981 | 108.2 | 22.2 | 20.5% | 108.2 | 22.2 | 20.5% | 108.2 | 22.2 | 20.5% |
| 1983 | 124.8 | 19.0 | 15.3% | 124.8 | 19.0 | 15.3% | 124.8 | 19.0 | 15.3% |
| 1985 | 126.9 | 18.5 | 14.6% | 126.9 | 18.5 | 14.6% | 126.9 | 18.5 | 14.6% |
| 1987 | 127.4 | 24.0 | 18.9% | 127.4 | 24.0 | 18.9% | 127.4 | 24.0 | 18.9% |
| 1988 | 126.8 | 23.2 | 18.3% | 129.0 | 23.6 | 18.3% | 131.4 | 24.0 | 18.2% |
| 1989 | 126.4 | 23.2 | 18.3% | 130.7 | 23.9 | 18.3% | 135.8 | 24.7 | 18.2% |
| 1990 | 126.1 | 23.1 | 18.4% | 132.6 | 24.3 | 18.3% | 140.6 | 25.6 | 18.2% |
| 1991 | 125.9 | 23.2 | 18.4% | 134.7 | 24.7 | 18.4% | 145.9 | 26.4 | 18.1% |
| 1992 | 125.8 | 23.2 | 18.4% | 137.0 | 25.2 | 18.4% | 151.6 | 27.4 | 18.1% |
| 1993 | 125.9 | 23.2 | 18.4% | 139.5 | 25.6 | 18.4% | 158.0 | 28.4 | 17.9% |
| 1994 | 126.0 | 23.3 | 18.5% | 142.2 | 26.1 | 18.4% | 165.0 | 29.4 | 17.8% |
| 1995 | 126.4 | 23.3 | 18.5% | 145.1 | 26.6 | 18.3% | 172.8 | 30.5 | 17.6% |
| 1996 | 126.8 | 23.4 | 18.5% | 148.3 | 27.1 | 18.3% | 181.5 | 31.7 | 17.4% |
| 1997 | 127.4 | 23.5 | 18.4% | 151.8 | 27.7 | 18.2% | 191.1 | 32.9 | 17.2% |
| 1998 | 128.2 | 23.6 | 18.4% | 155.7 | 28.3 | 18.2% | 201.9 | 34.2 | 16.9% |
| 1999 | 129.1 | 23.7 | 18.4% | 159.9 | 28.9 | 18.1% | 213.9 | 35.6 | 16.6% |
| 2000 | 130.2 | 23.8 | 18.3% | 164.4 | 29.5 | 18.0% | 227.4 | 37.1 | 16.3% |
| Growth Rates: | | | | | | | | | |
| 73-87 | 4.8% | 5.0% | | 4.8% | 5.0% | | 4.8% | 5.0% | |
| 87-91 | -0.3% | -0.9% | | 1.4% | 0.7% | | 3.4% | 2.4% | |
| 87-20 | 0.2% | -0.1% | | 2.0% | 1.6% | | 4.6% | 3.4% | |

NOTE: This table does not include postdoctoral employment or unemployment.
SOURCE: Estimated by NRC.

Table A-23. Historical and Projected Vacancy Ratios, 1973-2000, Other Behavioral Scientists

| | Annual Averages | | | | | |
|---|---|---|---|---|---|---|
| | Total | | | R&D | | |
| Year | Vacancies | PhDs | Ratio | Vacancies | Post-docs | Ratio |
| 1973-78 | 1152 | 1211 | 0.95 | 289 | 97 | 2.97 |
| 1978-83 | 930 | 1093 | 0.85 | 120 | 124 | 0.97 |
| 1983-87 | 875 | 943 | 0.93 | 185 | 120 | 1.54 |
| 1987-95 | | | | | | |
| Low | 649 | 814 | 0.80 | 142 | 120 | 1.18 |
| Mid | 927 | 882 | 1.05 | 191 | 120 | 1.59 |
| High | 1353 | 955 | 1.42 | 250 | 120 | 2.08 |

NOTE: Assumes that Ph.D. production changes in proportion to enrollment assumptions and postdoc production remains constant.
Graduate model

SOURCE: Estimated by NRC.

Table A-24. Classifications of Fields

## NIH[a]

**BIOMEDICAL SCIENCES**

**General Medical and Biological Sciences**

* Anatomy
* Biochemistry
* Biophysics
* Microbiology
* Pathology
* Pharmacology
* Physiology
Multidisciplinary[b]
Radiation, Nonclin.
Entomology
* Genetics
* Nutrition
Hydrobiology
Ecology
* Cell Biology
* Zoology
Botany
* Biology NEC
* Other Gen. Med. and Bio. Sci.
* Environ. Sciences
* Toxicology

**Mathematics, Physical Sciences, Engineering, Other**

Mathematics
Chemistry
Physics
Earth and Related Sciences
Agricultural Fields
Engineering
Engineering, Health-Related

**Other Health-Related Fields**

* Biostatistics
* Epidemiology

**Community and Environmental Health**

Accident Prevention
Disease Prevention and Control
Maternal & Child Health
Dental Public Health
Mental Health
Hospital & Medical Care
Other Community Health
Radiological Health
Water Pollution Control
Air Pollution
Environmental Engineering
Food Protection
Occupational Health
Health Administration
Social Work
Pharmacy
Other Health-Rel. Profs.
Other Env. Health Fields

## ADAMHA[c]

**BIOMEDICAL SCIENCES**

* **Anatomy**

Anatomy
Histology
Pathology
Experimental Pathology
Cell Biology
Embryology

* **Biology**

Radiobiology
Entomology
Nutrition
Molecular Biology
Zoology
Botany
Developmental Biology
Neurobiology
Teratology
Aging Process
Oral Biology

* **Genetics**

Genetics
Mutagenesis

* **Microbiology/Immunology**

Microbiology
Bacteriology
Immunology
Mycology
Parasitology
Virology

* **Pharmacology**

Pharmacology

* **Physiology**

Physiology
Reproductive Physiology
Endocrinology
Communicative Sciences
Physiological Optics

* **Toxicology**

Toxicology
Aquatic
Environmental
Forensic
Inhalation
Occupational/Safety

**Mathematics, Physical Sciences, Engineering, Other**

**Chemistry**

Biochemistry
Biomaterials
Chemistry
Polymer Chemistry
Medicinal Chemistry
Organic Chemistry
Physical Chemistry
Inorganic Chemistry

**Physics/Engineering**

Biophysics
Radiation Physics
Biomedical Engineering
Environ. Engineering
Physics
Engineering

**Other Health-Related Fields**

**Statistics/Epidemiology/Computer Sciences**

* Biostatistics
* Epidemiology
Information Sciences
Mathematics
Statistics
Computer Sciences

## NAS[d]

* **BASIC BIOMEDICAL SCIENCES**

Anatomy
Embryology
Human and Animal Physiology
Biochemistry
Molecular Biology
Biomathematics
Biometrics and Biostatistics
Biomedical Engineering
Biophysics
Environmental Sciences
Environmental Health
General Biological Sciences
Human and Animal Genetics
Immunology
Parasitology
Microbiology
Bacteriology
Neurosciences
Human and Animal Pathology
Pharmaceutical Chemistry
Human and Animal Pharmacology
Pharmacy
Public Health
Epidemiology
Hospital Administration
Veterinary Medicine
Zoology
Cell Biology/Cytology
Nutritional Sciences/Dietetics
Food Science and Technology
Endocrinology
Toxicology
Other Biological Sciences
Medicine and Surgery
Dentistry
Optometry, Ophthalmology
General Health, Medical Sciences
Other Health/Medical Sciences

Table A-24. Classifications of Fields (continued)

| NIH[a] | ADAMHA[c] | NAS[d] |
|---|---|---|
| BEHAVIORAL SCIENCES | BEHAVIORAL SCIENCES | BEHAVIORAL SCIENCES |
| Psychology | Psychology | Psychology |
| General and Experimental | Experimental and General | General |
| Comparative and Animal | Psychophysics | Clinical |
| Physiological | Physiological Psychology and Psychobiology | Cognitive |
| Developmental | Developmental and Child | Counseling and Guidance |
| Personality | Personality | Developmental and |
| Gerontological | | |
| Social-Psychological Aspects | Social | Educational |
| Abnormal | Community and Ecological | School |
| Clinical | | Experimental |
| Education, Counseling, and Guidance | Other Behavioral Sciences | Comparative |
| Other Psychological | | Physiological |
| | Health Administration and Public Health | Psychometrics |
| Other Behavioral Sciences | Education and Guidance | Quantitative |
| | Sociology | Social |
| Sociology | Demography or Population Dynamics | Industrial and Organizational |
| Social Psychology-Sociological Aspects | Anthropology | Personality |
| Anthropology | Linguistics | Human Engineering |
| Social Sciences and Related Disciplines | Social Sciences and Related Disciplines | Behavior/Ethology |
| Other Fields | Economics | Other Psychology |
| | Political Science | |
| CLINICAL SCIENCES | Bioethics | Other Behavioral Sciences |
| | Social/Behavioral Sciences | |
| Internal Medicine | | Anthropology |
| Allergy | CLINICAL SCIENCES | Sociology |
| Pediatrics | | Audiology and Speech Pathology |
| Geriatrics | Psychiatry | |
| Obstetrics-Gynecology | Other Clinical Medicine | |
| Radiology | Nursing | |
| Surgery | Social Work | |
| Otorhinolaryngology | Clinical Psychology | |
| Ophthalmology | | |
| Anesthesiology | | |
| Neuropsychiatry | | |
| Neurology | | |
| Psychiatry | | |
| Preventive Medicine | | |
| Other Clinical Medicine | | |
| Veterinary Medicine | | |
| Clinical Dentistry | | |
| NURSING RESEARCH | | |

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* These fields correspond to those defined by the committee as the Basic Biomedical Sciences. See NRC (1975-81, 1977 Report, p. 29).

[a] Since 1962, NIH has used a classification scheme called the Discipline/Specialty/Field Code (DSF) to classify areas of training for its trainees and fellows. The major categories of that scheme are shown in this table. They have been grouped into 4 broad areas of research that the committee has established for purposes of this study.

[b] Most of the trainees in the Medical Scientist Training Program are classified in this category.

[c] These fields represent the lexicon established by ADAMHA to classify areas of training for its NRSA trainees and fellows.

[d] These fields are used by the National Research Council's Survey of Doctorates and Survey of Doctorate Recipients to identify fields of Ph.D. specialization and fields of employment.

RS990-4.2

# BIOMEDICAL AND BEHAVIORAL RESEARCH SCIENTISTS: THEIR TRAINING AND SUPPLY

## Volume II: Statistical Tables

Committee on Biomedical and Behavioral
Research Personnel

Office of Scientific and Engineering Personnel
National Research Council

in collaboration with the
Institute of Medicine

NATIONAL ACADEMY PRESS
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**NOTICE:** The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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# BIOMEDICAL AND BEHAVIORAL RESEARCH SCIENTISTS: THEIR TRAINING AND SUPPLY

## Volume II: Statistical Tables

# Foreword

In 1988 the National Institutes of Health Planning and Policy Research Branch tasked Quantum Research Corporation to review and update a series of statistical tables required for the National Research Council's 1989 study of biomedical and behavioral personnel and training needs. These tables had originally been published in the National Research Council's 1985 report on *Personnel Needs and Training for Biomedical and Behavioral Research.*

The resulting statistical tables are provided in this volume. Data for these tables were obtained from the Association of American Medical Colleges, the American Dental Association, the American Medical Association, the Bureau of the Census, the National Science Foundation, the Department of Education's National Center for Education Statistics, the National Research Council, the Alcohol, Drug Abuse, and Mental Health Administration, and several National Institutes of Health units. When necessary, special computer summaries were run against NIH database files, such as the Consolidated Grant Applicant File (CGAF) and the Trainee and Fellow File (TFF), to secure the needed information.

There are two sets of tables derived from the AAMC Medical School Faculty Roster database: A1.-A3. and A21.-A25. The first set was tabulated from the 1987 file by AAMC staff to extend the time series of A1.-A3.; the latter set was tabulated from the 1988 file by QRC staff for NIH/PPRB to extend the time series *Updated Trends and Some Observations About Medical School Faculties.* Differences between the 1987 file and the updated 1988 file as well as differences in the definitions needed to extend the two time series, have resulted in the tabulation of slightly different numbers of faculty.

These statistical tables are maintained at the NIH (PPRB), in computerized form as a series of Microsoft Excel spreadsheets with an associated table retrieval subsystem. All seventy-one detailed tables, as well as the three summary tables, are stored on a single high-density 3.5" diskette. The tables will be updated annually, and available at the NIH (PPRB).

# Table of Contents

## Summary Tables

1. Current Trends in Supply/Demand Indicators in the Clinical Sciences
2. Current Trends in Supply/Demand Indicators for Biomedical Science Ph.D.s
3. Current Trends in Supply/Demand Indicators for Behavioral Science Ph.D.s

## Clinical Sciences Tables

A1. Students in U.S. Medical Schools, by Type of Institutional Control, 1961-1987
A2. Faculty in U.S. Medical Schools, by Type of Institutional Control, 1961-1987
A3. Clinical Sciences Faculty/Student Ratio, by Type of Institutional Control, 1964-87
A4. M.D. Graduates of U.S. Medical Schools, by Type of Institutional Control, 1961-1987
A5. Full-Time Budgeted Vacancies on U.S. Medical School Faculties, by Type of Institutional Control, 1961-87
A6. Primary Acitivity of Physicians in the U.S., 1963-87
A7. R and D Expenditures in U.S. Medical Schools, by Type of Institutional Control, 1962-87 ($ thousands)
A8. Professional Service Income in the U.S. Medical Schools, by Type of Institutional Control, 1962-87 ($ thousands)
A9. Average Clinical R and D Expenditures and Professional Service Income per U.S. Medical School, by Type of Institutional Control, 1962-87 (1972 $, thousands)
A10. Clinical R and D Expenditures + Professional Service Income in U.S. Medical Schools, by Type of Institutional Control, 1962-87 (1972 $, thousands)
A11-1. Sources of Revenue in U.S. Medical Schools, 1959-87 (current $, millions)
A11-2. Sources of Revenue in U.S. Medical Schools, 1959-87 (1972 $, millions)
A12. Students in U.S. Dental Schools, by Type of Institutional Control, 1961-88
A13. Faculty in U.S. Dental Schools, by Type of Institutional Control, 1969-87
A14-1. Research and Development Revenue in U.S. Dental Schools, by Type of Institutional Control, 1968-87 ($ thousands)
A14-2. Research and Development Expenditures in U.S. Dental Schools, by Type of Institutional Control, 1968-87 ($ thousands)
A15. Dental Clinic Revenue in U.S. Dental Schools, by Type of Institutional Control, 1968-87 ($ thousands)
A16. Dental School Tuition Revenue, by Type of Institutional Control, 1968-87 ($ thousands)
A17. Revenue from State and Local Governments in U.S. Dental Schools, by Type of Institutional Control, 1968-87 ($ thousands)
A18. Total Revenue in U.S. Dental Schools, by Type of Institutional Control, 1968-87 ($ thousands)
A19. Full-Time Budgeted Vacancies on U.S. Dental School Faculties, by Type of Institutional Control, 1969-87
A20. NIH Trainees and Fellows in Clinical Dental Research, 1977-86
A21. Number of New Faculty and Percentage of New Faculty Among Full-Time Faculty in U.S. Medical Schools, by Year and Degree Type, 1970-88
A22. Number and Percentage of New Faculty in U.S. Medical Schools Who Have Had Postdoctoral Research Training, by Department and Degree Type, 1982-88
A23. Composition of Total Faculty and New Faculty in Basic Science Departments of U.S. Medical Schools, by Degree, 1970-88
A24. Composition of Total Faculty and New Faculty in Clinical Departments of U.S. Medical Schools, by Degree, 1970-88
A25. Number of Faculty Who Had Returned to Full-Time Positions After Leaving Academic Medicine in 1970 for One or More Years

## Biomedical Sciences Tables

B1. Biomedical Science Enrollments in Colleges and Universities, by Type of Institutional Control, 1960-87
B2. First-Year Graduate Enrollment in the Biomedical Sciences, 1960-87
B3. Biomedical Science Degrees Awarded in Colleges and Universities, by Type of Institutional Control, and Postdoctoral Appointments in All Employment Sectors, 1960-87
B4. Total Undergraduate Degree-Credit Enrollment, Total B.A. Degrees Awarded, and Ratio of Biomedical Science B.A.s to Total B.A.s, by Type of Institutional Control, 1960-87
B5. Ph.D.s Employed in the Biomedical Sciences, 1960-87
B6. National Expenditures for Health-Related R and D, 1960-89 ($ millions)
B7. NIH Research Grant Expenditures, 1965-88 ($ millions)
B8. Biomedical Science R and D Expenditures in Colleges and Universities, by Type of Institutional Control, 1960-87 ($ millions)
B9. Average Biomedical Science R and D Expenditures per School in Colleges and Universities, by Type of Institutional Control, 1972-87 (1972 $, thousands)
B10. Indirect Costs of NIH-Sponsored Research Grants at Institutions of Higher Education, 1970-88
B11. Ph.D.s Academically Employed in the Biomedical Sciences, by Employment Status and Type of Institution, 1973-87
B12-1. Permanent Attrition Rates of U.S. Medical School Faculty, by Department and Degree Type, 1970-88
B12-2. One-Year-Out Attrition Rates of U.S. Medical School Faculty, by Department and Degree Type, 1970-88
B13. Postdoctoral Research Training of New Faculty in U.S. Medical Schools, by Department and Degree Type, 1970-87
B14. Graduate School Attrition Rates in the Biomedical Sciences, 1963-74
B15. Percent of the Postdoctoral Population in the Biomedical Sciences Who Had Earned Their Doctorates More Than 2, 3, or 4 Years Earlier, 1973-87

## Behavioral Sciences Tables

C1. Behavioral Science Enrollments in Colleges and Universities, by Type of Institutional Control, 1960-87
C2. Graduate Enrollment in Clinical Psychology, Nonclinical Psychology, and Other Behavioral Sciences, and Ratio of Clinical Psychology Ph.D.s to Total Psychology Ph.D.s, by Type of Institutional Control, 1960-88
C3. First-Year Graduate Enrollment in the Behavioral Sciences, 1960-88
C4. Psychology Enrollments in Colleges and Universities, B.A. Degrees Awarded in Psychology, and Ratio of Psychology B.A.s to Total B.A.s, by Type of Institutional Control, 1960-88
C5. Sociology Enrollments in Colleges and Universities, B.A. Degrees Awarded in Sociology, and Ratio of Sociology B.A.s to Total B.A.s, by Type of Institutional Control, 1960-88
C6. Anthropology Enrollments in Colleges and Universities, B.A. Degrees Awarded in Anthropology, and Ratio of Anthropology B.A.s to Total B.A.s, by Type of Institutional Control, 1960-88
C7. Graduate Enrollment in Sociology/Anthropology (Interdisciplinary), by Type of Institutional Control, 1978-88

C8. Speech Pathology/Audiology Enrollments in Colleges and Universities, B.A. Degrees Awarded in Speech Pathology/Audiology, and Ratio of Speech Pathology/Audiology B.A.s to Total B.A.s, by Type of Institutional Control, 1971-88
C9. Total Undergraduate Degree-Credit Enrollment, Total B.A. Degrees, and B.A. Degrees Awarded in the Behavioral Sciences, by Type of Institutional Control, 1960-87
C10-1. Behavioral Science Ph.D. Degrees Awarded in Colleges and Universities, by Type of Institutional Control, 1961-87
C10-2. Behavioral Science Ph.D. Degrees Awarded in Colleges and Universities, by Type of Institutional Control, 1961-87 (Continued)
C11-1. Behavioral Science Postdoctoral Appointments, 1973-87
C11-2. Behavioral Science Postdoctoral Appointments, 1973-87 (Continued)
C12. Ph.D.s Employed in All Behavioral Science Fields, 1973-87
C13. Ph.D.s Employed in Clinical Psychology, 1973-87
C14. Ph.D.s Employed in Nonclinical Psychology, 1973-87
C15. Ph.D.s Employed in Other Behavioral Sciences, 1973-87
C16. Behavioral Sciences Faculty/Student Ratios, 1964-87
C17. Ph.D.s Academically Employed in the Behavioral Sciences, by Employment Status and Type of Institution, 1973-87
C18. Behavioral Science R and D Expenditures, by Type of Institutional Control, 1960-87 ($ millions)
C19. Average Behavioral Science R and D Expenditures per School in Colleges and Universities, by Type of Institutional Control, 1972-87 (1972 $, thousands)
C20. Psychology R and D Expenditures in Colleges and Universities, by Type of Institutional Control, 1964-87
C21. Sociology R and D Expenditures in Colleges and Universities, by Type of Institutional Control, 1964-87
C22. Graduate Enrollment in the Behavioral Sciences, by Sex, 1967-88 (percent of field total)
C23. Graduate School Attrition Rates in the Behavioral Sciences, 1963-74

## Miscellaneous Tables

D1. Estimates of the Total Population of the United States, by Age Group, 1971-2081 (in thousands)
D2. NIH/ADAMHA/HRSA Expenditures for Research Training Programs, 1971-88 ($ millions)
D3. NRSA Training Expenditures as a Percentage of NIH/ADAMHA/HRSA Research Obligations, 1971-88 ($ millions)

## Published Sources of Data

## SUMMARY TABLE 1. Current Trends in Supply/Demand Indicators in the Clinical Sciences

| | Fiscal Year | | | | | | | | | | | Annual Growth Rate | Latest Annual Change | Average Annual Change |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 1/ | 1984 | 1985 | 1986 | 1987 | | | |
| 1. SUPPLY INDICATORS (New Entrants): | | | | | | | | | | | | | | |
| a. Professional doctorates participating in NIH training grants and fellowships 2/ | 2,203 | 1,879 | 1,780 | 1,906 | 1,938 | 2,026 | 2,108 | 2,184 | 2,265 | 2,162 | n/a | -0.2% | -4.5% | -5 |
| b. M.D. degrees awarded | 13,614 | 14,391 | 14,966 | 15,135 | 15,673 | 15,985 | 15,801 | 16,369 | 16,321 | 15,979 | 15,818 | 1.5% | -1.0% | 220 |
| 2. DEMAND INDICATORS: | | | | | | | | | | | | | | |
| a. Expenditures for clinical R & D in medical schools (1972 $, mil.) | $268 | $282 | $273 | $296 | $288 | $295 | $315 | $349 | $389 | $420 | $444 | 5.2% | 5.7% | $18 |
| b. Professional service income in medical schools (1972 $, mil.) | $391 | $406 | $441 | $493 | $526 | $612 | $740 | $806 | $957 | $990 | $1,121 | 11.1% | 13.2% | $73 |
| c. Total revenue (all sources), (1972 $, mil.) | $2,781 | $2,839 | $2,965 | $3,195 | $3,293 | $3,488 | $3,793 | $4,033 | $4,367 | $4,681 | $5,141 | 6.3% | 9.8% | $236 |
| d. Budgeted vacancies in medical schools: | | | | | | | | | | | | | | |
| (1) Clinical departments | 1,865 | 2,000 | 2,100 | 2,279 | 2,231 | 2,264 | 2,270 | 2,402 | 2,572 | 2,345 | 2,510 | 3.0% | 7.0% | 65 |
| (2) Basic science departments | 638 | 697 | 721 | 776 | 656 | 668 | 671 | 705 | 801 | 757 | 785 | 2.1% | 3.7% | 15 |
| e. Clinical faculty/student ratio 3/ | 0.311 | 0.322 | 0.323 | 0.334 | 0.331 | 0.341 | 0.346 | 0.349 | 0.354 | 0.368 | 0.380 | 2.0% | 3.3% | 0.007 |
| 3. LABOR FORCE | | | | | | | | | | | | | | |
| a. M.D.s primarily engaged in research 4/ | 9,786 | 11,437 | 14,515 | 15,377 | 17,901 | 16,743 | 18,535 | 22,945 | 23,268 | 17,847 | 16,586 | 5.4% | -7.1% | 680 |
| b. Full-time faculty in clinical departments | 30,349 | 32,622 | 34,057 | 36,665 | 37,716 | 40,148 | 41,938 | 43,443 | 45,007 | 47,193 | 48,834 | 4.9% | 3.5% | 1,849 |
| c. NIH research grants awarded to M.D.s: 5/ | | | | | | | | | | | | | | |
| (1) Number of competing grants | 1,645 | 1,926 | 2,060 | 1,772 | 1,729 | 1,600 | 1,768 | 2,013 | 1,971 | 1,925 | n/a | 1.8% | -2.3% | 31 |
| (2) % of total competing grants | 37% | 33% | 31% | 33% | 31% | 29% | 29% | 32% | 28% | 27% | n/a | -3.4% | -3.6% | -1.1% |
| d. M.D. applicants for NIH research grants: | | | | | | | | | | | | | | |
| (1) Number of competing applicants | 4,184 | 4,302 | 4,239 | 4,182 | 4,301 | 4,281 | 4,313 | 4,621 | 4,865 | 5,080 | n/a | 2.2% | 4.4% | 100 |
| (2) % of total competing applicants | 34% | 33% | 31% | 31% | 30% | 28% | 28% | 29% | 28% | 28% | n/a | -2.1% | 0.0% | -0.7% |
| e. M.D. success rate: | | | | | | | | | | | | | | |
| (1) M.D. awards/M.D. applicants | 36% | 41% | 45% | 40% | 39% | 35% | 39% | 41% | 39% | 36% | n/a | 0.0% | -7.7% | 0.0% |
| (2) M.D. awardees/all awardees | 37% | 33% | 32% | 34% | 32% | 29% | 30% | 32% | 29% | 28% | n/a | -3.0% | -3.4% | -1.0% |
| 4. ENROLLMENTS: | | | | | | | | | | | | | | |
| a. Medical students | 58,266 | 60,424 | 62,582 | 64,020 | 65,412 | 66,484 | 66,886 | 67,437 | 67,086 | 66,607 | 65,918 | 1.2% | -1.0% | 765 |
| b. Residents and clinical fellows 6/ | 44,795 | 46,444 | 50,188 | 52,491 | 52,871 | 57,504 | 59,138 | 60,442 | 63,507 | 60,875 | 61,539 | 3.2% | 1.1% | 1,674 |
| c. Total | 103,061 | 106,868 | 112,770 | 116,511 | 118,283 | 123,988 | 126,024 | 127,879 | 130,593 | 127,482 | 127,457 | 2.1% | 0.0% | 2,440 |

(See footnotes and item sources on the following page)

## SUMMARY TABLE 1. Footnotes and Sources

### Footnotes

1/ Financial data from the University of Washington and Mayo Medical School were included for the first time in 1983.

2/ Includes Fogarty International Center programs.

3/ Ratio of full-time clinical faculty to a 4-yrear weighted average of total enrollments of medical students, residents and clinical fellows(WS), where $(WS)_t = 1/6(S_t + 2S_{t-1} + 2S_{t-2} + S_{t-3})$.

4/ There is some question about the interpretation of these data since they include many trainees in graduate medical programs. 1984 data are previously unpublished; AMA reports them to be accurate to within 100 persons".

5/ Data for M.D.s do NOT exclude those who may also have a Ph.D. degree. As a result, the sum of percent M.D. awardees and percent Ph.D. awardees (Summary Table 2), can be greater than 100%.

6/ The residents and clinical fellows reported here include only those in accredited programs affiliated with medical schools.

### Sources

### Item

1a. Data were extracted from the NIH Trainee and Fellow File (TFF); post-professional doctorates with activated awards were selected. FY is fiscal year of maximum time on duty.
1b. From Appendix Table A4., Total M.D. Graduates. Annual tabulations by the AAMC from the Medical School Faculty Roster database.

2a. From Appendix Table A7., Total Estimated Clinical R&D (1972 dollars). See Appendix Table A7 for description of method for estimating clinical R&D expenditures from AAMC annual tabulations of total R&D expenditures by medical schools, and for the implicit GNP price deflator for computing 1972 dollars.
2b. From Appendix Table A8., Total Professional Service Income (1972 dollars). Annual tabulations by the AAMC.
2c. From Appendix Table A11-2., Total Revenue, All Schools (1972 dollars). Journal of the American Medical Association, annual education issues.
2d. From Appendix Table A5., Clinical Sciences Departments and Basic Science Departments. Journal of the American Medical Association, annual education issues.
2e. From Appendix Table A3., which was computed from Tables A1. and A2. All data are from the AAMC; students represent a 4-year weighted average of total medical school enrollments.

3a. From Appendix Table A6., Research. Data are from the AMA's publication "Physician Characteristics and Distribution in the U.S." 1984 data were previously unpublished, see Appendix Table A6.
3b. From Appendix Table A2., Full-time, All Schools, Clinical Departments. Annual tabulations by the AAMC from the Medical School Faculty Roster database.
3c. Data were extracted from the NIH Consolidated Grant Applicant File (CGAF). Research grants were defined as K, M, P, R, and U activity codes; successful new and competing applications by persons with M.D. or M.D. - equivalent degrees were selected. All grants awarded and grants awards to M.D.s were summed by year; M.D. grants / all grants were then calculated.
3d. Data were derived from the same population as in item 3c. This item represents persons (applicants) while item 3c. represents grants. M.D. and M.D. - equivalent applicants were identified and summed for each year. Percent of total competing applicants was then calculated.
3e. Data were derived from the same population as in item 3c. Awards refer to grants, applicants and awardees refer to persons.

4a. From Appendix Table A1., Medical Students, All Schools. Annual tabulations by the AAMC.
4b. From Appendix Table A1., computed sum of Intern & Residents and Clinical Fellows, All Schools. Annual tabulations by the AAMC.
4c. From Appendix Table A1., Total Enrollment, All Schools. Sum of Medical Students, Interns & Residents, and Clinical Fellows; from the AAMC.

## SUMMARY TABLE 2. Current Trends in Supply/Demand Indicators for Biomedical Science Ph.D.s

| | Fiscal Year | | | | | | | | | | | Annual Growth Rate | Latest Annual Change |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | | |
| 1. SUPPLY INDICATORS (New Entrants): | | | | | | | | | | | | | |
| a. Ph.D. production | 3,465 | 3,518 | 3,644 | 3,823 | 3,846 | 3,960 | 3,788 | 3,902 | 3,787 | 3,864 | 3,969 | 1.4% | 2.7% |
| b. % of Ph.D.s without specific employment prospects at graduation | 7.2% | 6.0% | 5.2% | 4.8% | 5.5% | 5.4% | 6.8% | 5.3% | 5.7% | 5.9% | 5.9% | -2.0% | 0.0% |
| c. Postdoctoral appointments (SDR adjusted) | 6,312 | n/a | 7,268 | n/a | 8,026 | n/a | 7,827 | n/a | 8,364 | n/a | 8,172 | 2.6% | -1.1% |
| d. Postdoctoral appointments (GSESP survey) | 6,055 | 6,364 | n/a | 6,622 | 6,782 | 7,330 | 7,350 | 7,926 | 8,309 | 8,738 | 9,273 | 4.4% | 6.1% |
| e. B.A. degrees awarded | 51,783 | 49,701 | 47,717 | 45,106 | 42,297 | 40,750 | 38,322 | 37,115 | 37,364 | 37,597 | 37,284 | -3.2% | -0.8% |
| 2. DEMAND INDICATORS: | | | | | | | | | | | | | |
| a. National expenditures for health-related R&D (1972 $, bil.) | $3.93 | $4.12 | $4.31 | $4.45 | $4.46 | $4.58 | $4.93 | $5.38 | $5.81 | $6.24 | $6.87 | 5.7% | 10.1% |
| b. Biomedical science R&D expenditures in colleges and universities (1972 $, bil.) | $1.27 | $1.34 | $1.35 | $1.42 | $1.49 | $1.52 | $1.57 | $1.68 | $1.83 | $2.00 | $2.17 | 5.5% | 8.5% |
| c. NIH research grant expenditures (1972 $, bil.) | $1.01 | $1.08 | $1.18 | $1.21 | $1.19 | $1.16 | $1.25 | $1.38 | $1.56 | $1.58 | $1.80 | 5.9% | 13.9% |
| d. Ph.D. faculty/student ratio 1/ | 0.154 | n/a | 0.168 | n/a | 0.184 | n/a | 0.184 | n/a | n/a | n/a | n/a | 3.0% | 0.0% |
| 3. LABOR FORCE 2/ | | | | | | | | | | | | | |
| a. Total | 55,031 | n/a | 62,332 | n/a | 68,806 | n/a | 71,423 | n/a | 79,515 | n/a | 85,339 | 4.5% | 3.7% |
| b. Academic (excl. postdoctorates) | 30,384 | n/a | 33,566 | n/a | 36,482 | n/a | 36,963 | n/a | 41,032 | n/a | 43,025 | 3.5% | 2.4% |
| c. Industry | 6,893 | n/a | 8,455 | n/a | 9,928 | n/a | 11,819 | n/a | 13,706 | n/a | 15,928 | 8.7% | 8.1% |
| d. Government | 4,568 | n/a | 5,080 | n/a | 5,398 | n/a | 5,988 | n/a | 6,479 | n/a | 7,049 | 4.4% | 4.4% |
| e. Hospitals/clinics | 2,297 | n/a | 2,726 | n/a | 2,799 | n/a | 2,946 | n/a | 3,307 | n/a | 3,629 | 4.7% | 4.9% |
| f. Nonprofit | 1,543 | n/a | 1,858 | n/a | 2,088 | n/a | 2,102 | n/a | 2,460 | n/a | 2,651 | 5.6% | 3.9% |
| g. Self-employed | 862 | n/a | 1,185 | n/a | 1,857 | n/a | 1,910 | n/a | 2,254 | n/a | 2,634 | 11.8% | 8.4% |
| h. Other (incl. postdoctorates and FFRDC laboratories) | 7,687 | n/a | 8,786 | n/a | 9,487 | n/a | 8,743 | n/a | 9,449 | n/a | 9,518 | 2.2% | 0.4% |
| i. Unemployed and seeking | 797 | n/a | 676 | n/a | 767 | n/a | 952 | n/a | 828 | n/a | 905 | 1.3% | 4.6% |
| 4. NIH GRANTS 3/ | | | | | | | | | | | | | |
| a. NIH research grants awarded to Ph.D.s: | | | | | | | | | | | | | |
| (1) Number of competing grants | 2825 | 3937 | 4506 | 3616 | 3622 | 3763 | 4021 | 4224 | 4910 | 5037 | n/a | 6.6% | 2.6% |
| (2) % of total competing grants | 64% | 68% | 69% | 68% | 65% | 67% | 66% | 66% | 69% | 72% | n/a | 1.3% | 4.3% |
| b. Ph.D. applicants for NIH research grants: | | | | | | | | | | | | | |
| (1) Number of competing applicants | 8,228 | 9,001 | 9,462 | 9,171 | 9,736 | 10,876 | 10,617 | 11,006 | 12,369 | 12,830 | n/a | 5.1% | 3.7% |
| (2) % of total competing applicants | 67% | 68% | 69% | 69% | 67% | 70% | 68% | 69% | 70% | 70% | n/a | 0.5% | 0.0% |
| c. Ph.D. success rate: | | | | | | | | | | | | | |
| (1) Ph.D. awards/Ph.D. applicants | 32% | 41% | 44% | 37% | 36% | 33% | 36% | 36% | 37% | 37% | n/a | 1.6% | 0.0% |
| (2) Ph.D. awardees/all awardees | 65% | 69% | 70% | 68% | 67% | 69% | 68% | 67% | 70% | 73% | n/a | 1.3% | 4.3% |

(Summary Table 2 continued on the next page)

## SUMMARY TABLE 2. Continued

| | Fiscal Year | | | | | | | | | | | Annual Growth Rate | Latest Annual Change |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | | |
| 5. BIOMEDICAL ENROLLMENTS: | | | | | | | | | | | | | |
| a. Total biomedical graduate and undergraduate enrollments | 556,064 | 546,542 | 517,123 | 507,798 | 501,907 | 498,006 | 502,999 | 505,437 | n/a | n/a | n/a | -1.4% | 0.5% |
| b. Estimated undergraduate 4/ | 437,525 | 420,686 | 388,833 | 378,161 | 371,272 | 367,128 | 372,687 | 375,269 | n/a | n/a | n/a | -2.2% | 0.7% |
| c. Medical and dental schools | 79,279 | 81,934 | 84,761 | 86,502 | 88,254 | 89,105 | 89,121 | 88,865 | 87,674 | 86,170 | 84,591 | 0.7% | -1.8% |
| d. Graduate | 39,260 | 43,922 | 43,529 | 43,135 | 42,381 | 41,773 | 41,191 | 41,303 | 42,433 | 43,237 | 44,495 | 1.3% | 2.9% |
| e. First-year graduate 5/ | 9,763 | 9,612 | 8,836 | 8,348 | 8,279 | 8,105 | 8,043 | 8,320 | 8,451 | 8,529 | 8,609 | -1.3% | 0.9% |

1/ Ratio of academically employed Ph.D.s to a weighted average of total graduate and undergraduate enrollments (WS), where (WS)t = 0.25(US)t + 0.75(GS)t, (US)t = 1/3(Ut + Ut-1 + Ut-2), and (GS)t = 1/3(Gt + Gt-1 + Gt-2).

2/ Latest annual change represents average annual growth rate from 1985-87.

3/ Data for Ph.D.s do NOT exclude those who may also have an M.D. degree. As a result, the sum of percent Ph.D. awardees and percent M.D. awardees (Summary Table 1), can be greater than 100%.

4/ Estimated by the formula Ui = (Ai + 2/Bi +2)Ci, where Ui = biomedical science undergraduate enrollment in year i; Ai+2 = biomedical science baccalaureate degrees awarded in year i+2 (excluding health professions); Bi+2 = total baccalaureate degrees awared in year i+2; Ci = total undergraduate degree-credit enrollment in year i (excluding first professional).

5/ Represents full-time students in doctorate-granting institutions only.

## Sources

### Item

1a. From Appendix Table B3., Total Ph.D. Degrees Awarded. Data were tabulated from NRC's Doctorate Records File (DRF) by NRC staff.

1b. Data were tabulated from the NRC's DRF by NRC staff.

1c. From Appendix Table B5., Academic Postdoc Appointments. Data were tabulated from the NRC's Survey of Doctorate Recipients (SDR) by NRC staff.

1d. From NSF/NIH Survey of Graduate Science and Engineering Students and Postdoctorates. Differences between these data and postdoc data from the SDR are due in part to differences in the academic fields included.

1e. From Appendix Table B3., Total B.A. Degrees Awarded. Data were provided by the Department of Education's National Center for Education Statistics.

2a. From Appendix Table B6., Total, 1972 Dollars. Data are from the NIH Data Book.

2b. From Appendix Table B8., Total, 1972 Dollars. Data are from the NIH Data Book.

2c. From Appendix Table B7., Total NIH Research Grant Expenditures, 1972 Dollars. Data are from the NIH Data Book.

2d. From Appendix Table B5., Academically Employed Ph.D.s, and Table B1., Students. See footnote above for calculation of weighted average of total graduate and undergraduate enrollments. Faculty data were tabulated from the SDR by NRC staff; student enrollment data are from various sources, see Table B1.

3. From Appendix Table B5., some details on B5 are aggregated. Data were tabulated from the SDR by NRC staff.

4. Data were extracted from the NIH Consolidated Grant Applicant File (CGAF). Research grants were defined as K, M, P, R, and U activity codes; new and competing applications by persons with Ph.D. or Ph.D. - equivalent degrees were selected. Applicants, awardees and awards were totalled by year.

5a. - d. From Appendix Table B1. Data from Department of Education, AAMC, AMA, ADA and NSF. See B1 for detailed source information.

5e. From Appendix Table B2. Data are from the NSF/NIH Survey of Graduate Science and Engineering Students and Postdoctorates.

## SUMMARY TABLE 3. Current Trends in Supply/Demand Indicators for Behavioral Science Ph.D.s 1/

| | Fiscal Year | | | | | | | | | | | Annual Growth | Latest Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | Rate | Change |
| 1. SUPPLY INDICATORS (New Entrants): | | | | | | | | | | | | | |
| a. Ph.D. production | 4,246 | 4,207 | 4,245 | 4,192 | 4,472 | 4,188 | 4,318 | 4,184 | 3,986 | 4,032 | 3,980 | -0.6% | -1.3% |
| b. % of Ph.D.s without specific employment prospects at graduation | 15.6% | 16.7% | 15.5% | 14.9% | 14.6% | 16.5% | 18.4% | 18.5% | 16.7% | 15.4% | 17.1% | 0.9% | 11.0% |
| c. Postdoctoral appointments SDR (adjusted) | 997 | n/a | 1,111 | n/a | 972 | n/a | 1,039 | n/a | 1,622 | n/a | 1,279 | 2.5% | -10.6% |
| d. Postdoctoral appointments (GSESP survey) | 576 | 582 | n/a | 650 | 637 | 612 | 656 | 615 | 614 | 721 | 671 | 1.5% | -6.9% |
| e. B.A. degrees awarded | 81,491 | 75,899 | 71,109 | 68,859 | 65,733 | 64,386 | 60,316 | 58,611 | 56,930 | 57,850 | 60,368 | -3.0% | 4.4% |
| 2. DEMAND INDICATORS: | | | | | | | | | | | | | |
| a. Behavioral science R&D expenditures in colleges and universities (1972 $, mil.) | $103.8 | $103.0 | $105.9 | $111.6 | $114.4 | $102.5 | $99.8 | $97.9 | $101.9 | $108.6 | $112.6 | 0.8% | 3.7% |
| b. Ph.D. faculty/student ratio 2/ | 0.035 | n/a | 0.038 | n/a | 0.042 | n/a | 0.045 | n/a | n/a | n/a | n/a | 4.3% | 3.6% |
| 3. LABOR FORCE: 3/ | | | | | | | | | | | | | |
| Ph.D.s employed in behavioral science fields: | | | | | | | | | | | | | |
| a. Total | 44,283 | n/a | 49,322 | n/a | 53,815 | n/a | 58,811 | n/a | 64,253 | n/a | 67,706 | 4.3% | 2.7% |
| b. Academic (excl. postdoctorates) | 25,582 | n/a | 26,896 | n/a | 28,235 | n/a | 29,776 | n/a | 31,719 | n/a | 31,809 | 2.2% | 0.1% |
| c. Business | 1,793 | n/a | 1,901 | n/a | 2,764 | n/a | 3,390 | n/a | 3,125 | n/a | 2,384 | 2.9% | -11.9% |
| d. Government (incl. FFRDC laboratories) | 2,931 | n/a | 3,268 | n/a | 3,351 | n/a | 3,559 | n/a | 3,281 | n/a | 3,960 | 3.1% | 10.3% |
| e. Hospitals/clinics | 5,595 | n/a | 6,157 | n/a | 6,481 | n/a | 6,584 | n/a | 7,124 | n/a | 7,913 | 3.5% | 5.5% |
| f. Nonprofit | 1,487 | n/a | 2,164 | n/a | 2,120 | n/a | 1,865 | n/a | 2,166 | n/a | 2,651 | 6.0% | 11.2% |
| g. Self-employed | 3,725 | n/a | 5,209 | n/a | 7,352 | n/a | 9,707 | n/a | 12,137 | n/a | 14,550 | 14.6% | 9.9% |
| h. Other (incl. postdoctorates) | 2,416 | n/a | 2,958 | n/a | 2,780 | n/a | 3,017 | n/a | 3,891 | n/a | 3,546 | 3.9% | -4.4% |
| i. Unemployed and seeking | 754 | n/a | 749 | n/a | 732 | n/a | 913 | n/a | 810 | n/a | 893 | 1.7% | 5.1% |
| 4. BEHAVIORAL SCIENCE ENROLLMENTS: | | | | | | | | | | | | | |
| a. Total undergraduate and graduate enrollments | 721,816 | 712,713 | 676,603 | 668,593 | 658,407 | 654,146 | 637,570 | 647,429 | n/a | n/a | n/a | -1.5% | 1.5% |
| b. Estimated undergraduate 4/ | 663,527 | 648,933 | 612,802 | 604,773 | 593,627 | 589,815 | 574,462 | 583,700 | n/a | n/a | n/a | -1.8% | 1.6% |
| c. Total graduate | 58,289 | 63,780 | 63,801 | 63,820 | 64,780 | 64,331 | 63,108 | 63,713 | 65,640 | 65,269 | 65,100 | 1.1% | -0.3% |
| d. First-year graduate 5/ | 11,606 | 11,695 | 10,390 | 9,938 | 10,227 | 9,846 | 9,650 | 9,408 | 9,477 | 9,872 | 9,555 | -1.9% | -3.2% |

(See footnotes and item sources on the following page)

# SUMMARY TABLE 3. Footnotes and Sources

## Footnotes

1/ Behavioral sciences include anthropology, sociology, psychology, and speech pathology/audiology. Numbers in the report may differ from previous reports because of taxonomy changes. Speech pathology/audiology was excluded in the Committee's 1983 report but is included here.

2/ Ratio of academically employed Ph.D.s to a 4-year weighted average of total graduate and undergraduate enrollments (WS), where $(WS)t = 1/6(St + 2St-2 + St-3)$.

3/ Latest annual change represents average annual growth rate from 1985-87.

4/ Estimated by the formula $Ui = (Ai+2/Bi+2)Ci$ where $Ui$ = behavioral science undergraduate enrollment in year I; $Ai+2$ = behavioral science B.A. degrees awarded in year $i+2$; $Bi+2$ = total B.A. degrees awarded in year $i+2$; $Ci$ = total undergraduate enrollment in year i.

5/ Represents full-time students in doctorate-granting institutions only.

## Sources

### Item

1a. From Appendix Table C10., Total Ph.D. Degrees Awarded. Data were tabulated from the NRC's Doctorate Records File (DRF) by NRC staff.

1b. Data were tabulated from the DRF by NRC staff.

1c. From Appendix Table C11-1., Total Postdoc Appointments. Data were tabulated from the NRC's Survey of Doctorate Recipients (SDR) by NRC staff.

1d. From NSF/NIH Survey of Graduate Science and Engineering Students and Postdoctorates (GSESP). Differences between these data and postdoc data from the SDR are due in part to differences in the academic fields included.

1e. From Appendix Table C9., Total B.A. Degrees Awarded. Data were provided by the Department of Education's National Center for Education Statistics.

2a. From Appendix Table C18., Total, 1972 Dollars. Data are from NSF Survey of Scientific and Engineering Expenditures at Universities and Colleges.

2b. From Appendix Table C16., which is derived from Tables C1., C4. - C6., C8., and C17. The ratio is academically employed Ph.D.s to a weighted average of students.

3. From Appendix Table C12., some details are aggregated. Data were tabulated from the SDR by NRC staff.

4a. - c. From Appendix Table C1. Data are from the Department of Education and the NSF/NIH GSESP survey.

4d. From Appendix Table C3., First-Year Full-Time Graduate Enrollment in Doctorate-Granting Institutions. Data are from the NSF/NIH GSESP survey.

## APPENDIX TABLE A1. Students in U.S. Medical Schools, by Type of Institutional Control, 1961-1987 1/

| | All Schools | | | | Public Schools | | | | Private Schools | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fiscal Year | Total | Medical Students | Interns & Residents | Clinical Fellows | Total | Medical Students | Interns & Residents 2/ | Clinical Fellows 2,3,4/ | Total | Medical Students | Interns & Residents | Clinical Fellows 2,3/ |
| 1961 | 49,899 | 30,688 | 16,970 | 2,241 | 25,115 | 15,954 | 8,362 | 799 | 24,784 | 14,734 | 8,608 | 1,442 |
| 1962 | 52,014 | 31,077 | 17,362 | 3,575 | 26,412 | 16,211 | 8,237 | 1,964 | 25,602 | 14,866 | 9,125 | 1,611 |
| 1963 | 52,219 | 31,238 | 17,380 | 3,601 | 26,198 | 16,432 | 8,292 | 1,474 | 26,021 | 14,806 | 9,088 | 2,127 |
| 1964 | 54,181 | 32,001 | 17,956 | 4,224 | 27,292 | 17,012 | 8,408 | 1,872 | 26,889 | 14,989 | 9,548 | 2,352 |
| 1965 | 55,170 | 32,106 | 18,991 | 4,073 | 27,561 | 17,116 | 8,999 | 1,446 | 27,609 | 14,990 | 9,992 | 2,627 |
| 1966 | 56,101 | 32,482 | 19,950 | 3,669 | 28,610 | 17,406 | 9,959 | 1,245 | 27,491 | 15,076 | 9,991 | 2,424 |
| 1967 | 57,618 | 33,142 | 20,290 | 4,186 | 29,358 | 17,906 | 9,932 | 1,520 | 28,260 | 15,236 | 10,358 | 2,666 |
| 1968 | 61,684 | 34,318 | 22,044 | 5,322 | 32,308 | 18,631 | 11,330 | 2,347 | 29,376 | 15,687 | 10,714 | 2,975 |
| 1969 | 63,530 | 35,102 | 23,462 | 4,966 | 33,153 | 19,024 | 11,930 | 2,199 | 30,377 | 16,078 | 11,532 | 2,767 |
| 1970 | 67,785 | 37,978 | 27,003 | 2,804 | 35,309 | 21,082 | 12,848 | 1,379 | 32,476 | 16,896 | 14,155 | 1,425 |
| 1971 | 71,500 | 40,476 | 27,440 | 3,584 | 37,733 | 22,616 | 13,956 | 1,161 | 33,767 | 17,860 | 13,484 | 2,423 |
| 1972 | 81,564 | 43,576 | 31,722 | 6,266 | 44,169 | 24,500 | 16,657 | 3,012 | 37,395 | 19,076 | 15,065 | 3,254 |
| 1973 | 86,914 | 47,523 | 33,117 | 6,274 | 47,429 | 26,830 | 16,954 | 3,645 | 39,485 | 20,693 | 16,163 | 2,629 |
| 1974 | 91,515 | 50,242 | 35,644 | 5,629 | 50,230 | 28,753 | 18,808 | 2,669 | 41,285 | 21,489 | 16,836 | 2,960 |
| 1975 | 95,273 | 54,076 | 36,213 | 4,984 | 51,677 | 30,826 | 19,159 | 1,692 | 43,596 | 23,250 | 17,054 | 3,292 |
| 1976 | 100,152 | 56,244 | 38,370 | 5,538 | 55,561 | 32,417 | 20,625 | 2,519 | 44,591 | 23,827 | 17,745 | 3,019 |
| 1977 | 103,061 | 58,266 | 39,431 | 5,364 | 57,364 | 33,932 | 21,141 | 2,291 | 45,697 | 24,334 | 18,290 | 3,073 |
| 1978 | 106,868 | 60,424 | 41,222 | 5,222 | 59,880 | 35,633 | 21,992 | 2,255 | 46,988 | 24,791 | 19,230 | 2,967 |
| 1979 | 112,770 | 62,582 | 44,951 | 5,237 | 64,024 | 37,265 | 24,219 | 2,540 | 48,746 | 25,317 | 20,732 | 2,697 |
| 1980 | 116,511 | 64,020 | 46,775 | 5,716 | 66,335 | 38,234 | 25,170 | 2,931 | 50,176 | 25,786 | 21,605 | 2,785 |
| 1981 | 118,283 | 65,412 | 46,577 | 6,294 | 67,091 | 39,425 | 24,628 | 3,038 | 51,192 | 25,987 | 21,949 | 3,256 |
| 1982 | 123,988 | 66,484 | 50,381 | 7,123 | 70,601 | 40,132 | 26,791 | 3,678 | 53,387 | 26,352 | 23,590 | 3,445 |
| 1983 | 126,024 | 66,886 | 51,704 | 7,434 | 71,323 | 40,410 | 27,178 | 3,735 | 54,701 | 26,476 | 24,526 | 3,699 |
| 1984 | 127,879 | 67,437 | 53,297 | 7,145 | 73,251 | 40,795 | 28,835 | 3,621 | 54,628 | 26,642 | 24,462 | 3,524 |
| 1985 | 130,593 | 67,086 | 54,255 | 9,252 | 73,603 | 40,584 | 29,183 | 3,836 | 56,990 | 26,502 | 25,072 | 5,416 |
| 1986 5/ | 127,482 | 66,607 | 53,338 | 7,537 | 72,991 | 40,159 | 28,945 | 3,887 | 54,491 | 26,448 | 24,393 | 3,650 |
| 1987 6/ | 127,457 | 65,918 | 53,232 | 8,307 | 73,319 | 39,544 | 29,360 | 4,415 | 54,138 | 26,374 | 23,872 | 3,892 |

1/ Figures were obtained from the Association of American Medical Colleges (1972-88, annual tabulations).
Because AAMC data were incomplete, figures for all items in 1962 and for clinical fellows in 1969 were obtained from the American Medical Association (1960-1988).

2/ Includes only individuals in accredited programs affiliated with medical schools (public schools, all years; private schools, 1972 and 1973).

3/ Data include graduate students in 1972 ,1973 (public schools) and 1974 (private schools).

4/ Interpolated in 1974.

5/ Data for Georgetown clinical fellows and residents are missing.

6/ Data for Tufts clinical fellows and residents are missing; data for East Tennessee medical students are missing.

## APPENDIX TABLE A2. Faculty in U.S. Medical Schools, by Type of Institutional Control, 1961-1987

| | Full-Time 1/ | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Schools | | | Public Schools | | | Private Schools | | | Part-Time 2/ | | | Volunteer 2/ | | |
| Fiscal Year | Total | Basic Sci. Depts. | Clinical Depts. | Total | Basic Sci. Depts. | Clinical Depts. | Total | Basic Sci. Depts. | Clinical Depts. | Total | Basic Sci. Depts. | Clinical Depts. | Total | Basic Sci. Depts. | Clinical Depts. |
| 1961 | 11,224 | 4,023 | 7,201 | 5,054 | 1,849 | 3,205 | 6,170 | 2,174 | 3,996 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1962 | 12,040 | 4,342 | 7,698 | 5,448 | 2,011 | 3,437 | 6,592 | 2,331 | 4,261 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1963 | 13,602 | 4,693 | 8,909 | 6,190 | 2,202 | 3,988 | 7,412 | 2,491 | 4,921 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1964 | 15,015 | 5,541 | 9,474 | 7,095 | 2,705 | 4,390 | 7,916 | 2,832 | 5,084 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1965 | 15,882 | 5,233 | 10,649 | 7,609 | 2,452 | 5,157 | 8,273 | 2,781 | 5,492 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1966 | 17,118 | 5,671 | 11,447 | 8,218 | 2,666 | 5,552 | 8,898 | 3,003 | 5,895 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1967 | 19,297 | 5,877 | 13,420 | 9,268 | 2,907 | 6,361 | 10,029 | 2,970 | 7,059 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1968 | 22,293 | 6,639 | 15,654 | 11,066 | 3,364 | 7,702 | 11,227 | 3,275 | 7,952 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1969 | 23,034 | 7,048 | 15,986 | 11,126 | 3,567 | 7,559 | 11,908 | 3,481 | 8,427 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1970 | 24,093 | 7,287 | 16,806 | 11,870 | 3,778 | 8,092 | 12,223 | 3,509 | 8,714 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1971 | 27,539 | 8,283 | 19,256 | 13,385 | 4,300 | 9,085 | 14,154 | 3,983 | 10,171 | 7,792 | n/a | n/a | 49,928 | n/a | n/a |
| 1972 | 30,170 | 8,714 | 21,456 | 14,588 | 4,642 | 9,946 | 15,582 | 4,072 | 11,510 | 7,403 | 925 | 6,478 | 56,732 | 3,499 | 53,233 |
| 1973 | 33,265 | 9,381 | 23,884 | 15,455 | 4,790 | 10,665 | 17,810 | 4,591 | 13,219 | 6,870 | 880 | 5,990 | 61,895 | 2,817 | 59,078 |
| 1974 | 34,878 | 9,928 | 24,950 | 16,307 | 5,238 | 11,069 | 18,571 | 4,690 | 13,881 | 7,616 | 793 | 6,823 | 62,115 | 3,946 | 58,169 |
| 1975 | 37,010 | 10,164 | 26,846 | 17,820 | 5,488 | 12,332 | 19,190 | 4,676 | 14,514 | 10,011 | 1,027 | 8,984 | 64,393 | 3,896 | 60,497 |
| 1976 | 39,346 | 10,743 | 28,603 | 19,690 | 5,944 | 13,746 | 19,656 | 4,799 | 14,857 | 7,824 | 800 | 7,024 | 70,453 | 4,405 | 66,048 |
| 1977 | 41,650 | 11,301 | 30,349 | 20,819 | 6,383 | 14,436 | 20,831 | 4,918 | 15,913 | 7,738 | 685 | 7,053 | 74,193 | 4,473 | 69,720 |
| 1978 | 44,358 | 11,736 | 32,622 | 23,240 | 6,766 | 16,474 | 21,118 | 4,970 | 16,148 | 7,268 | 749 | 6,519 | 78,986 | 4,649 | 74,337 |
| 1979 | 46,662 | 12,605 | 34,057 | 24,406 | 7,164 | 17,242 | 22,256 | 5,441 | 16,815 | 9,692 | 922 | 8,770 | 86,096 | 5,353 | 80,743 |
| 1980 | 49,496 | 12,831 | 36,665 | 26,444 | 7,461 | 18,983 | 23,052 | 5,370 | 17,682 | 9,052 | 919 | 8,133 | 82,635 | 4,876 | 77,759 |
| 1981 | 50,532 | 12,816 | 37,716 | 26,555 | 7,471 | 19,084 | 23,977 | 5,345 | 18,632 | 9,550 | 1,017 | 8,533 | 89,077 | 5,100 | 83,977 |
| 1982 | 53,371 | 13,223 | 40,148 | 27,572 | 7,707 | 19,865 | 25,799 | 5,516 | 20,283 | 10,451 | 1,043 | 9,408 | 93,099 | 5,517 | 87,582 |
| 1983 | 55,525 | 13,587 | 41,938 | 29,160 | 7,963 | 21,197 | 26,365 | 5,624 | 20,741 | 8,997 | 975 | 8,022 | 105,590 | 5,779 | 99,811 |
| 1984 | 57,003 | 13,560 | 43,443 | 29,274 | 7,782 | 21,492 | 27,729 | 5,778 | 21,951 | 9,864 | 917 | 8,947 | 104,240 | 5,947 | 98,293 |
| 1985 | 58,774 | 13,767 | 45,007 | 29,603 | 7,973 | 21,630 | 29,171 | 5,794 | 23,377 | 10,141 | 885 | 9,256 | 112,792 | 6,089 | 106,703 |
| 1986 | 61,397 | 14,204 | 47,193 | 31,544 | 8,353 | 23,191 | 29,853 | 5,851 | 24,002 | 10,495 | 977 | 9,518 | 113,338 | 6,226 | 107,112 |
| 1987 3/ | 63,313 | 14,479 | 48,834 | 32,199 | 8,396 | 23,803 | 31,114 | 6,083 | 25,031 | 8,231 | 767 | 7,464 | 118,768 | 6,472 | 112,296 |

1/ Figures were obtained from the Association of American Medical Colleges (1972-88), special tabulations prepared annually. Because AAMC data were incomplete, total full-time faculty figures for 1962 were obtained from the American Medical Association (1960-88); public and private figures for 1962 were estimated by the committee.

2/ From the American Medical Association (1960-88).

3/ Data for University of California-San Francisco clinical faculty are missing.

## APPENDIX TABLE A3. Clinical Sciences Faculty/Student Ratio, by Type of Institutional Control, 1964-87 1/

| | All Schools | | | Public Schools | | | Private Schools | | |
|---|---|---|---|---|---|---|---|---|---|
| Fiscal Year | Clinical Faculty (CF) | 4-Yr. Weighted Avg. Enrollment (WS) | Clinical Faculty/ Student Ratio (CF/WS) | Clinical Faculty (CF) | 4-Yr. Weighted Avg. Enrollment (WS) | Clinical Faculty/ Student Ratio (CF/WS) | Clinical Faculty (CF) | 4-Yr. Weighted Avg. Enrollment (WS) | Clinical Fac./ Student Ratio (CF/WS) |
| 1964 | 9,474 | 52,091 | 0.182 | 4,390 | 26,271 | 0.167 | 5,084 | 25,820 | 0.197 |
| 1965 | 10,649 | 53,331 | 0.200 | 5,157 | 26,826 | 0.192 | 5,492 | 26,505 | 0.207 |
| 1966 | 11,447 | 54,504 | 0.210 | 5,552 | 27,419 | 0.202 | 5,895 | 27,085 | 0.218 |
| 1967 | 13,420 | 55,724 | 0.241 | 6,361 | 28,165 | 0.226 | 7,059 | 27,558 | 0.256 |
| 1968 | 15,654 | 57,382 | 0.273 | 7,702 | 29,301 | 0.263 | 7,952 | 28,081 | 0.283 |
| 1969 | 15,986 | 59,706 | 0.268 | 7,559 | 30,849 | 0.245 | 8,427 | 28,857 | 0.292 |
| 1970 | 16,806 | 62,639 | 0.268 | 8,092 | 32,598 | 0.248 | 8,714 | 30,040 | 0.290 |
| 1971 | 19,256 | 65,969 | 0.292 | 9,085 | 34,494 | 0.263 | 10,171 | 31,475 | 0.323 |
| 1972 | 21,456 | 70,611 | 0.304 | 9,946 | 37,234 | 0.267 | 11,510 | 33,376 | 0.345 |
| 1973 | 23,884 | 76,805 | 0.311 | 10,665 | 41,090 | 0.260 | 13,219 | 35,714 | 0.370 |
| 1974 | 24,950 | 83,329 | 0.299 | 11,069 | 45,193 | 0.245 | 13,881 | 30,135 | 0.364 |
| 1975 | 26,846 | 88,949 | 0.302 | 12,332 | 48,527 | 0.254 | 14,514 | 40,422 | 0.359 |
| 1976 | 28,603 | 93,440 | 0.306 | 13,746 | 51,134 | 0.269 | 14,857 | 42,306 | 0.351 |
| 1977 | 30,349 | 97,571 | 0.311 | 14,436 | 53,678 | 0.269 | 15,913 | 43,893 | 0.363 |
| 1978 | 32,622 | 101,428 | 0.322 | 16,474 | 56,235 | 0.293 | 16,148 | 45,193 | 0.357 |
| 1979 | 34,057 | 105,463 | 0.323 | 17,242 | 59,012 | 0.292 | 16,815 | 46,451 | 0.362 |
| 1980 | 36,665 | 109,808 | 0.334 | 18,983 | 61,918 | 0.307 | 17,682 | 47,890 | 0.369 |
| 1981 | 37,716 | 113,952 | 0.331 | 19,084 | 64,615 | 0.295 | 18,632 | 49,337 | 0.378 |
| 1982 | 40,148 | 117,724 | 0.341 | 19,865 | 66,913 | 0.297 | 20,283 | 50,812 | 0.399 |
| 1983 | 41,938 | 121,180 | 0.346 | 21,197 | 68,840 | 0.308 | 20,741 | 52,339 | 0.396 |
| 1984 | 43,443 | 124,364 | 0.349 | 21,492 | 70,698 | 0.304 | 21,951 | 53,666 | 0.409 |
| 1985 | 45,007 | 127,065 | 0.354 | 21,630 | 72,225 | 0.299 | 23,377 | 54,839 | 0.426 |
| 1986 | 47,193 | 128,408 | 0.368 | 23,191 | 73,004 | 0.318 | 24,002 | 55,405 | 0.433 |
| 1987 | 48,834 | 128,581 | 0.380 | 23,803 | 73,293 | 0.325 | 25,031 | 55,288 | 0.453 |

1/ Faculty is defined as all full-time faculty employed in clinical science departments of U.S. medical schools. Students are defined as a 4-year weighted average of enrollments, i.e.,$(WS)_t = 1/6(S_t + 2S_{t-1} + 2S_{t-2} + S_{t-3})$, where S = total enrollments of medical students, interns, residents, and clinical fellows. Totals may not sum due to rounding. See Appendix Tables A1 and A2 for supporting data.

## APPENDIX TABLE A4. M.D. Graduates of U.S. Medical Schools, by Type of Institutional Control, 1961-1987

| Fiscal Year | M.D. Graduates 1/ Total | Public | Private | Number of Medical Schools 2/ Total | Public | Private |
|---|---|---|---|---|---|---|
| 1961 | 6,994 | n/a | n/a | 86 | 44 | 42 |
| 1962 | 7,168 | n/a | n/a | 86 | 44 | 42 |
| 1963 | 7,264 | n/a | n/a | 87 | 44 | 43 |
| 1964 | 7,336 | n/a | n/a | 88 | 45 | 43 |
| 1965 | 7,409 | n/a | n/a | 88 | 45 | 43 |
| 1966 | 7,574 | n/a | n/a | 91 | 48 | 43 |
| 1967 | 7,743 | n/a | n/a | 96 | 53 | 43 |
| 1968 | 7,973 | n/a | n/a | 98 | 54 | 44 |
| 1969 | 8,059 | n/a | n/a | 100 | 56 | 44 |
| 1970 | 8,367 | n/a | n/a | 102 | 58 | 44 |
| 1971 | 9,005 | 4,891 | 4,114 | 107 | 62 | 45 |
| 1972 | 9,558 | 5,295 | 4,263 | 110 | 64 | 46 |
| 1973 | 10,396 | 5,884 | 4,512 | 113 | 66 | 47 |
| 1974 | 11,365 | 6,441 | 4,924 | 113 | 66 | 47 |
| 1975 | 12,716 | 7,175 | 5,541 | 113 | 66 | 47 |
| 1976 | 13,634 | 7,534 | 6,100 | 115 | 68 | 47 |
| 1977 | 13,614 | 7,698 | 5,916 | 119 | 72 | 47 |
| 1978 | 14,391 | 8,284 | 6,107 | 123 | 74 | 49 |
| 1979 | 14,966 | 8,852 | 6,114 | 125 | 74 | 51 |
| 1980 | 15,135 | 8,840 | 6,295 | 126 | 75 | 51 |
| 1981 | 15,673 | 9,243 | 6,430 | 126 | 75 | 51 |
| 1982 | 15,985 | 9,545 | 6,440 | 127 | 75 | 52 |
| 1983 | 15,801 | 9,411 | 6,390 | 127 | 75 | 52 |
| 1984 | 16,369 | 9,792 | 6,577 | 127 | 75 | 52 |
| 1985 | 16,321 | 9,862 | 6,459 | 127 | 75 | 52 |
| 1986 3/ | 15,979 | 9,525 | 6,293 | 126 | 75 | 51 |
| 1987 4/ | 15,818 | 9,755 | 6,224 | 126 | 74 | 52 |

1/ Figures for 1961-70 were obtained from the American Medical Association (1960-88).
Figures for 1971-87 were obtained from the Association of American Medical Colleges (1972-88, annual tabulations). The 1983 figure for private schools includes an estimate from Columbia University.

2/ From the Association of American Medical Colleges (1972-88, annual tabulations).

3/ Data for George Washington University graduates are missing.

4/ Data for East Tennessee University graduates are missing; 1987 figures are April, 1987 estimates.

## APPENDIX TABLE A5. Full-Time Budgeted Vacancies on U.S. Medical School Faculties, by Type of Institutional Control, 1961-87 1/

| Fiscal Year | All Departments |  |  | Basic Science Departments |  |  | Clinical Science Departments |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  | Total | Public | Private | Total | Public | Private | Total | Public | Private |
| 1961 | 784 | n/a | n/a | 305 | n/a | n/a | 515 | n/a | n/a |
| 1962 | 836 | n/a | n/a | 348 | n/a | n/a | 488 | n/a | n/a |
| 1963 | 826 | n/a | n/a | 350 | n/a | n/a | 476 | n/a | n/a |
| 1964 | 915 | n/a | n/a | 401 | n/a | n/a | 514 | n/a | n/a |
| 1965 | 955 | n/a | n/a | 376 | n/a | n/a | 579 | n/a | n/a |
| 1966 | 1,115 | n/a | n/a | 443 | n/a | n/a | 672 | n/a | n/a |
| 1967 | 1,374 | n/a | n/a | 520 | n/a | n/a | 854 | n/a | n/a |
| 1968 | 1,585 | n/a | n/a | 570 | n/a | n/a | 1,015 | n/a | n/a |
| 1969 | 1,691 | n/a | n/a | 579 | n/a | n/a | 1,112 | n/a | n/a |
| 1970 | 1,634 | n/a | n/a | 541 | n/a | n/a | 1,093 | n/a | n/a |
| 1971 | 1,522 | 856 | 666 | 518 | 296 | 222 | 1,004 | 560 | 444 |
| 1972 | 1,757 | 1,111 | 646 | 511 | 328 | 183 | 1,246 | 783 | 463 |
| 1973 | 1,857 | 1,144 | 713 | 550 | 361 | 189 | 1,307 | 783 | 524 |
| 1974 | 2,079 | 1,339 | 740 | 601 | 388 | 213 | 1,478 | 951 | 527 |
| 1975 | 2,250 | 1,505 | 745 | 618 | 415 | 203 | 1,632 | 1,090 | 542 |
| 1976 | 2,446 | 1,588 | 858 | 664 | 467 | 197 | 1,782 | 1,121 | 661 |
| 1977 | 2,503 | 1,599 | 904 | 638 | 416 | 222 | 1,865 | 1,183 | 682 |
| 1978 | 2,697 | 1,782 | 915 | 697 | 484 | 213 | 2,000 | 1,298 | 702 |
| 1979 | 2,821 | 1,811 | 1,010 | 721 | 467 | 254 | 2,100 | 1,344 | 756 |
| 1980 | 3,055 | 1,971 | 1,084 | 776 | 489 | 287 | 2,279 | 1,482 | 797 |
| 1981 | 2,887 | 1,978 | 909 | 656 | 425 | 231 | 2,231 | 1,553 | 678 |
| 1982 | 2,932 | 1,931 | 1,001 | 668 | 432 | 236 | 2,264 | 1,499 | 765 |
| 1983 | 2,941 | 1,857 | 1,084 | 671 | 419 | 252 | 2,270 | 1,438 | 832 |
| 1984 | 3,107 | 1,890 | 1,217 | 705 | 443 | 262 | 2,402 | 1,447 | 955 |
| 1985 | 3,373 | 2,161 | 1,212 | 801 | 531 | 270 | 2,572 | 1,630 | 942 |
| 1986 | 3,102 | 1,875 | 1,227 | 757 | 467 | 290 | 2,345 | 1,408 | 937 |
| 1987 | 3,301 | 1,974 | 1,327 | 785 | 521 | 264 | 2,510 | 1,447 | 1,063 |

1/ Figures for 1961-70 were obtained from the American Medical Association (1960-88). Figures for 1971-87 were obtained from the Association of American Medical Colleges (1972-88, special tabulations prepared annually).

## APPENDIX TABLE A6. Primary Activity of Physicians in the U.S., 1963-87 1/

| Fiscal Year | Total Active /2 | | Patient Care | | Teaching | | Admin. | | Research 4/ | | Other | | Unclassified And Unknown Address | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| 1963 | 263,063 | 100.0 | 246,951 | 93.9 | 8,190 | 3.1 | 3,332 | 1.3 | 3,255 | 1.2 | n/a | - | 1,335 | 0.5 |
| 1964 | 270,885 | 100.0 | 253,543 | 93.6 | 8,869 | 3.3 | 3,512 | 1.3 | 3,627 | 1.3 | n/a | - | 1,333 | 0.5 |
| 1965 | 278,809 | 100.0 | 259,418 | 93.0 | 9,794 | 3.5 | 4,057 | 1.5 | 4,306 | 1.5 | n/a | - | 1,234 | 0.4 |
| 1966 | 287,163 | 100.0 | 266,766 | 92.9 | 10,503 | 3.7 | 4,143 | 1.4 | 4,445 | 1.5 | n/a | - | 1,306 | 0.5 |
| 1967 | 295,732 | 100.0 | 274,190 | 92.7 | 11,166 | 3.8 | 4,121 | 1.4 | 4,595 | 1.6 | n/a | - | 1,660 | 0.6 |
| 1968 3/ | 298,401 | 100.0 | 261,722 | 87.7 | 5,051 | 1.7 | 11,715 | 3.9 | 15,441 | 5.2 | 2,383 | 0.8 | 2,089 | 0.7 |
| 1969 | 305,047 | 100.0 | 270,737 | 88.8 | 5,149 | 1.7 | 12,107 | 4.0 | 12,375 | 4.1 | 2,598 | 0.9 | 5,865 | 1.9 |
| 1970 | 314,407 | 100.0 | 278,535 | 88.6 | 5,568 | 1.8 | 12,158 | 3.9 | 11,929 | 3.8 | 2,635 | 0.8 | 3,562 | 1.1 |
| 1971 | 325,435 | 100.0 | 287,248 | 88.3 | 5,844 | 1.8 | 12,076 | 3.7 | 10,898 | 3.3 | 2,633 | 0.8 | 6,736 | 2.1 |
| 1972 | 336,424 | 100.0 | 292,210 | 86.9 | 5,836 | 1.7 | 11,074 | 3.3 | 9,290 | 2.8 | 2,693 | 0.8 | 15,521 | 4.6 |
| 1973 | 343,755 | 100.0 | 295,257 | 85.9 | 6,183 | 1.8 | 11,959 | 3.5 | 8,332 | 2.4 | 2,636 | 0.8 | 19,388 | 5.6 |
| 1974 | 358,134 | 100.0 | 301,238 | 84.1 | 6,464 | 1.8 | 11,739 | 3.3 | 8,159 | 2.3 | 2,666 | 0.7 | 27,868 | 7.8 |
| 1975 | 372,293 | 100.0 | 311,937 | 83.8 | 6,445 | 1.7 | 11,161 | 3.0 | 7,944 | 2.1 | 2,793 | 0.8 | 32,013 | 8.6 |
| 1976 | 387,329 | 100.0 | 318,412 | 82.2 | 6,935 | 1.8 | 11,689 | 3.0 | 8,514 | 2.2 | 2,893 | 0.7 | 38,886 | 10.0 |
| 1977 | 392,913 | 100.0 | 332,393 | 84.6 | 6,673 | 1.7 | 11,954 | 3.0 | 9,786 | 2.5 | 2,813 | 0.7 | 29,296 | 7.5 |
| 1978 | 410,655 | 100.0 | 342,714 | 83.5 | 7,025 | 1.7 | 11,858 | 2.9 | 11,437 | 2.8 | 2,777 | 0.7 | 34,844 | 8.5 |
| 1979 | 426,226 | 100.0 | 356,783 | 83.7 | 7,523 | 1.8 | 12,118 | 2.8 | 14,515 | 3.4 | 2,790 | 0.7 | 32,497 | 7.6 |
| 1980 | 441,935 | 100.0 | 376,512 | 85.2 | 7,942 | 1.8 | 12,209 | 2.8 | 15,377 | 3.5 | 2,876 | 0.7 | 27,019 | 6.1 |
| 1981 | 450,112 | 100.0 | 389,369 | 86.5 | 7,202 | 1.6 | 13,250 | 2.9 | 17,901 | 4.0 | 3,023 | 0.7 | 19,367 | 4.3 |
| 1982 | 466,268 | 100.0 | 408,663 | 87.6 | 7,505 | 1.6 | 13,408 | 2.9 | 16,743 | 3.6 | 3,070 | 0.7 | 16,879 | 3.6 |
| 1983 | 482,635 | 100.0 | 423,361 | 87.7 | 7,783 | 1.6 | 13,828 | 2.9 | 18,535 | 3.8 | 3,290 | 0.7 | 15,838 | 3.3 |
| 1984 5/ | 500,553 | 100.0 | 437,089 | 87.3 | 7,802 | 1.6 | 13,913 | 2.8 | 22,945 | 4.6 | 3,352 | 0.7 | 15,452 | 3.1 |
| 1985 | 514,070 | 100.0 | 448,820 | 87.3 | 7,832 | 1.5 | 13,810 | 2.7 | 23,268 | 4.5 | 3,410 | 0.7 | 16,930 | 3.3 |
| 1986 | 522,325 | 100.0 | 462,126 | 88.5 | 7,721 | 1.5 | 14,399 | 2.8 | 17,847 | 3.4 | 3,657 | 0.7 | 16,575 | 3.2 |
| 1987 | 537,555 | 100.0 | 478,511 | 89.0 | 8,114 | 1.5 | 14,536 | 2.7 | 16,586 | 3.1 | 3,581 | 0.7 | 16,227 | 3.0 |

1/ From the American Medical Association (1963-88).

2/ Excludes temporary foreign; includes unknown address and unclassified.

3/ In 1968 the AMA revised its procedures for classifying physicians, making comparisons with early years extremely difficult. One effect was to drastically reduce the Teaching category and to increase the Administration and Research categories.

4/ In 1968 includes 8,029 fellows formerly included in the Patient Care category.

5/ Although previously unpublished, these data were obtained from the AMA and are reported to be "accurate to within 100" persons.

## APPENDIX TABLE A7. R and D Expenditures in U.S. Medical Schools, by Type of Institutional Control, 1962-87 ($ thousands)

| | Total R and D Expenditures | | | | | | | | Estimated Clinical R and D 4/ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Current Dollars 1/ | | | 1972 Dollars | | | Implicit GNP Price Deflator 2/ (1972 = 100.00) | NIH Clinical Research as a % of Total Research Obligations 3/ | 1972 Dollars | | |
| Fiscal Year | Total | Public | Private | Total | Public | Private | | | Total | Public | Private |
| 1962 | 208,573 | 85,491 | 123,082 | 295,848 | 121,264 | 174,584 | 70.50 | 12.0 | 35,502 | 14,552 | 20,950 |
| 1963 | 264,400 | 106,000 | 158,400 | 369,274 | 148,045 | 221,229 | 71.60 | 13.5 | 49,852 | 19,986 | 29,866 |
| 1964 | 310,412 | 128,710 | 181,702 | 426,977 | 177,043 | 249,934 | 72.70 | 15.0 | 64,046 | 26,556 | 37,490 |
| 1965 | 344,787 | 143,627 | 201,160 | 464,047 | 193,307 | 270,740 | 74.30 | 16.5 | 76,568 | 31,896 | 44,672 |
| 1966 | 377,028 | 155,960 | 221,068 | 490,922 | 203,073 | 287,849 | 76.80 | 18.0 | 88,366 | 36,553 | 51,813 |
| 1967 | 422,467 | 178,881 | 243,586 | 534,768 | 226,432 | 308,337 | 79.00 | 20.0 | 106,954 | 45,286 | 61,667 |
| 1968 | 470,958 | 202,440 | 268,518 | 570,167 | 245,085 | 325,082 | 82.60 | 22.5 | 128,288 | 55,144 | 73,144 |
| 1969 | 489,300 | 196,800 | 292,500 | 564,360 | 226,990 | 337,370 | 86.70 | 25.0 | 141,090 | 56,747 | 84,343 |
| 1970 | 498,066 | 205,962 | 292,104 | 544,930 | 225,341 | 319,589 | 91.40 | 28.0 | 152,580 | 63,096 | 89,485 |
| 1971 | 499,841 | 207,346 | 292,495 | 520,668 | 215,985 | 304,682 | 96.00 | 30.0 | 156,200 | 64,796 | 91,405 |
| 1972 | 558,120 | 227,638 | 330,482 | 558,120 | 227,638 | 330,482 | 100.00 | 32.0 | 178,598 | 72,844 | 105,754 |
| 1973 | 606,921 | 264,808 | 342,113 | 573,649 | 250,291 | 323,358 | 105.80 | 34.0 | 195,041 | 85,099 | 109,942 |
| 1974 | 657,287 | 300,479 | 356,808 | 566,627 | 259,034 | 307,593 | 116.00 | 34.0 | 192,653 | 88,071 | 104,582 |
| 1975 | 784,537 | 363,893 | 420,644 | 616,774 | 286,079 | 330,695 | 127.20 | 39.0 | 240,542 | 111,571 | 128,971 |
| 1976 | 839,170 | 385,857 | 453,313 | 626,714 | 288,168 | 338,546 | 133.90 | 37.0 | 231,884 | 106,622 | 125,262 |
| 1977 | 973,827 | 449,709 | 524,118 | 687,246 | 317,367 | 369,879 | 141.70 | 39.0 | 268,026 | 123,773 | 144,253 |
| 1978 | 1,046,121 | 490,029 | 556,092 | 688,011 | 322,281 | 365,730 | 152.05 | 41.0 | 282,085 | 132,135 | 149,949 |
| 1979 | 1,190,689 | 585,488 | 605,201 | 719,623 | 353,855 | 365,769 | 165.46 | 38.0 | 273,457 | 134,465 | 138,992 |
| 1980 | 1,352,409 | 677,085 | 675,324 | 757,992 | 379,489 | 378,502 | 178.42 | 39.0 | 295,617 | 148,001 | 147,616 |
| 1981 | 1,477,919 | 766,565 | 711,354 | 757,363 | 392,828 | 364,535 | 195.14 | 38.0 | 287,798 | 149,275 | 138,523 |
| 1982 | 1,605,585 | 828,954 | 776,631 | 776,095 | 400,693 | 375,402 | 206.88 | 38.0 | 294,916 | 152,263 | 142,653 |
| 1983 5/ | 1,787,532 | 937,510 | 850,022 | 828,981 | 434,777 | 394,204 | 215.63 | 38.0 | 315,013 | 165,215 | 149,798 |
| 1984 | 1,997,317 | 1,065,607 | 931,710 | 893,934 | 476,931 | 417,003 | 223.43 | 39.0 | 348,634 | 186,003 | 162,631 |
| 1985 | 2,301,421 | 1,229,256 | 1,072,165 | 997,149 | 532,607 | 464,543 | 230.80 | 39.0 | 388,888 | 207,717 | 181,172 |
| 1986 | 2,554,561 | 1,400,225 | 1,154,336 | 1,077,692 | 590,713 | 486,979 | 237.04 | 39.0 | 420,300 | 230,378 | 189,922 |
| 1987 | 2,787,925 | 1,500,175 | 1,287,750 | 1,138,579 | 612,666 | 525,913 | 244.86 | 39.0 | 444,046 | 238,940 | 205,106 |

1/ Figures were obtained from the Association of American Medical Colleges (1972-88, annual tabulations). Because AAMC data were incomplete, figures for 1963 and 1969 were obtained from the American Medical Association (1960-88). Items may not sum to totals due to rounding.

2/ From the U.S. Bureau of the Census (1988a,b).

3/ Estimates for 1962-75 were derived from data supplied by John James, Division of Research Grants, NIH. Other years were derived from the NSF Survey of Federal Support to Universities.

4/ See explanatory note on the following page.

5/ Financial data from the University of Washington and Mayo Medical School were included for the first time in 1983.

(Continued on the next page)

## NOTE TO APPENDIX TABLE A7

## ESTIMATING CLINICAL RESEARCH EXPENDITURES

An estimate of the amount of support for clinical R and D in U.S. medical schools is needed in order to refine the model of demand for clinical faculty. Data on total R and D expenditures in medical schools, the variable used in the demand models, are available from the AAMC. Data on clinical R and D expenditures, however, are unavailable.

An estimate of clinical R and D expenditures in medical schools has been derived using the proportion of total NIH obligations used to support clinical research. From 1969 to 1987, this proportion has increased by 56%. In the absence of any direct measurements, the percentages shown in the table offer the best available means of estimating clinical R and D expenditures in medical schools.

There is, of course, a serious problem of defining clinical research which clouds any attempt to measure its support. The NIH estimates were derived generally from its Central Scientific Classification System (CSCS) in which each research grant is classified according to its primary field or discipline. If that discipline falls within a group identified as clinical science, then the grant is tabulated as such. All program project and center grants are identified as clinical by the NIH.

The classification of any grant is admittedly subjective; estimates derived by this process are subject to considerable uncertainty. Other classification schemes in use at NIH would be likely to produce different estimates of clinical research from those derived from the CSCS system. But the latter have one advantage - - they were produced for a series of years under a constant definition. Thus, while the absolute levels may not be very precise, the change from year to year seems to have somewhat more validity.

## APPENDIX TABLE A8. Professional Service Income in the U.S. Medical Schools, by Type of Institutional Control, 1962-87 ($ thousands)

| Fiscal Year | Current Dollars 1/ | | | 1972 Dollars 2/ | | |
|---|---|---|---|---|---|---|
| | Total | Public | Private | Total | Public | Private |
| 1962 | 15,500 | 7,453 | 8,047 | 21,986 | 10,572 | 11,414 |
| 1963 | 16,680 | 8,624 | 8,056 | 23,296 | 12,045 | 11,251 |
| 1964 | 18,576 | 9,124 | 9,452 | 25,552 | 12,550 | 13,001 |
| 1965 | 21,839 | 11,534 | 10,305 | 29,393 | 15,524 | 13,869 |
| 1966 | 25,203 | 13,369 | 11,834 | 32,816 | 17,408 | 15,409 |
| 1967 | 30,252 | 16,407 | 13,845 | 38,294 | 20,768 | 17,525 |
| 1968 | 47,406 | 28,096 | 19,310 | 57,392 | 34,015 | 23,378 |
| 1969 | 65,300 | 37,600 | 27,700 | 75,317 | 43,368 | 31,949 |
| 1970 | 90,057 | 52,232 | 37,825 | 98,531 | 57,147 | 41,384 |
| 1971 | 115,803 | 68,379 | 47,504 | 120,711 | 71,228 | 49,483 |
| 1972 | 138,197 | 75,466 | 62,731 | 138,197 | 75,466 | 62,731 |
| 1973 | 158,984 | 87,763 | 71,221 | 150,268 | 82,952 | 67,317 |
| 1974 | 201,642 | 121,842 | 79,800 | 173,829 | 105,036 | 68,793 |
| 1975 | 305,331 | 168,798 | 136,533 | 240,040 | 132,703 | 107,337 |
| 1976 | 409,877 | 218,905 | 190,972 | 306,107 | 163,484 | 142,623 |
| 1977 | 553,664 | 263,965 | 289,699 | 390,730 | 186,284 | 204,445 |
| 1978 | 616,971 | 296,219 | 320,752 | 405,768 | 194,817 | 210,952 |
| 1979 | 729,439 | 361,104 | 368,335 | 440,855 | 218,242 | 222,613 |
| 1980 | 880,335 | 436,567 | 443,768 | 493,406 | 244,685 | 248,721 |
| 1981 | 1,026,296 | 500,402 | 525,894 | 525,928 | 256,432 | 269,496 |
| 1982 | 1,265,146 | 597,484 | 667,662 | 611,536 | 288,807 | 322,729 |
| 1983 3/ | 1,595,165 | 771,330 | 823,835 | 739,770 | 357,710 | 382,060 |
| 1984 | 1,800,954 | 868,772 | 932,182 | 806,048 | 388,834 | 417,214 |
| 1985 | 2,208,590 | 974,988 | 1,233,602 | 956,928 | 422,438 | 534,490 |
| 1986 | 2,346,965 | 1,158,401 | 1,188,564 | 990,113 | 488,694 | 501,419 |
| 1987 | 2,744,498 | 1,273,780 | 1,470,718 | 1,120,844 | 520,207 | 600,636 |

1/ This is income under control of the institution. An unknown amount is not under control of the institution and is not reported here. Figures were obtained from the Association of American Medical Colleges (1972-88, annual tabulations). Because AAMC data were incomplete, figures for 1969 were obtained from the American Medical Association (1960-88). Items may not sum to totals due to rounding.

2/ 1972 dollars were obtained by using the Implicit GNP Price Deflator (U.S. Bureau of the Census - - see Appendix Table A7).

3/ Financial data from the University of Washington and Mayo Medical School were included for the first time in 1983.

## APPENDIX TABLE A9. Average Clinical R and D Expenditures and Professional Service Income per U.S. Medical School, by Type of Institutional Control, 1962-87 1/ (1972 $ thousands)

| Fiscal Year | Clinical R and D Expenditures | | | | | | Professional Service Income | | | | | | Sum of Average Clinical R&D plus Professional Service Income per School | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Average per School | | | Number of Schools Reporting 2/ | | | Average per School | | | Number of Schools reporting 2/ | | | | | |
| | Total | Public | Private | Total | Public | Private | Total | Public | Private | Total | Public | Private | Total | Public | Private |
| 1962 | 413 | 331 | 499 | 86 | 44 | 42 | 733 | 587 | 951 | 30 | 18 | 12 | 1,146 | 918 | 1,450 |
| 1963 | 573 | 444 | 711 | 87 | 45 | 42 | 751 | 669 | 865 | 31 | 18 | 13 | 1,324 | 1,113 | 1,577 |
| 1964 | 745 | 604 | 893 | 86 | 44 | 42 | 824 | 738 | 929 | 31 | 17 | 14 | 1,569 | 1,342 | 1,821 |
| 1965 | 880 | 709 | 1,064 | 87 | 45 | 42 | 891 | 817 | 991 | 33 | 19 | 14 | 1,771 | 1,526 | 2,054 |
| 1966 | 993 | 778 | 1,234 | 89 | 47 | 42 | 994 | 967 | 1,027 | 33 | 18 | 15 | 1,987 | 1,745 | 2,261 |
| 1967 | 1,114 | 854 | 1,434 | 96 | 53 | 43 | 891 | 865 | 922 | 43 | 24 | 19 | 2,005 | 1,720 | 2,357 |
| 1968 | 1,323 | 1,003 | 1,742 | 97 | 55 | 42 | 1,025 | 1,031 | 1,016 | 56 | 33 | 23 | 2,347 | 2,033 | 2,758 |
| 1969 | 1,550 | 1,091 | 2,163 | 91 | 52 | 39 | 1,321 | 1,314 | 1,331 | 57 | 33 | 24 | 2,872 | 2,405 | 3,494 |
| 1970 | 1,526 | 1,088 | 2,131 | 100 | 58 | 42 | 1,388 | 1,361 | 1,427 | 71 | 42 | 29 | 2,914 | 2,448 | 3,558 |
| 1971 | 1,531 | 1,080 | 2,176 | 102 | 60 | 42 | 1,724 | 1,656 | 1,833 | 70 | 43 | 27 | 3,256 | 2,736 | 4,009 |
| 1972 | 1,734 | 1,235 | 2,404 | 103 | 59 | 44 | 1,946 | 1,841 | 2,091 | 71 | 41 | 30 | 3,680 | 3,075 | 4,495 |
| 1973 | 1,894 | 1,418 | 2,557 | 103 | 60 | 43 | 2,147 | 2,127 | 2,172 | 70 | 39 | 31 | 4,040 | 3,545 | 4,728 |
| 1974 | 1,736 | 1,334 | 2,324 | 111 | 66 | 45 | 2,381 | 2,283 | 2,548 | 73 | 46 | 27 | 4,117 | 3,618 | 4,872 |
| 1975 | 2,167 | 1,665 | 2,931 | 111 | 67 | 44 | 3,077 | 2,765 | 3,578 | 78 | 48 | 30 | 5,244 | 4,430 | 6,509 |
| 1976 | 2,070 | 1,591 | 2,784 | 112 | 67 | 45 | 3,644 | 3,270 | 4,195 | 84 | 50 | 34 | 5,715 | 4,861 | 6,978 |
| 1977 | 2,311 | 1,768 | 3,136 | 116 | 70 | 46 | 4,390 | 3,450 | 5,841 | 89 | 54 | 35 | 6,701 | 5,218 | 8,977 |
| 1978 | 2,351 | 1,835 | 3,124 | 120 | 72 | 48 | 4,363 | 3,479 | 5,701 | 93 | 56 | 37 | 6,714 | 5,314 | 8,825 |
| 1979 | 2,260 | 1,842 | 2,896 | 121 | 73 | 48 | 4,740 | 3,829 | 6,184 | 93 | 57 | 36 | 7,000 | 5,671 | 9,079 |
| 1980 | 2,443 | 2,000 | 3,141 | 121 | 74 | 47 | 5,140 | 4,078 | 6,909 | 96 | 60 | 36 | 7,583 | 6,078 | 10,050 |
| 1981 | 2,398 | 2,045 | 2,947 | 120 | 73 | 47 | 5,259 | 4,136 | 7,092 | 100 | 62 | 38 | 7,658 | 6,181 | 10,039 |
| 1982 | 2,398 | 2,058 | 2,911 | 123 | 74 | 49 | 5,995 | 4,658 | 8,068 | 102 | 62 | 40 | 8,393 | 6,716 | 10,980 |
| 1983 3/ | 2,561 | 2,233 | 3,057 | 123 | 74 | 49 | 6,914 | 5,420 | 9,319 | 107 | 66 | 41 | 9,475 | 7,652 | 12,376 |
| 1984 | 2,812 | 2,514 | 3,253 | 124 | 74 | 50 | 7,533 | 5,891 | 10,176 | 107 | 66 | 41 | 10,345 | 8,405 | 13,429 |
| 1985 | 3,062 | 2,770 | 3,484 | 127 | 75 | 52 | 8,699 | 6,401 | 12,147 | 110 | 66 | 44 | 11,761 | 9,170 | 15,632 |
| 1986 | 3,309 | 3,072 | 3,652 | 127 | 75 | 52 | 8,920 | 7,187 | 11,661 | 111 | 68 | 43 | 12,229 | 10,258 | 15,313 |
| 1987 | 3,496 | 3,229 | 3,870 | 127 | 74 | 53 | 9,919 | 7,650 | 13,347 | 113 | 68 | 45 | 13,415 | 10,879 | 17,217 |

1/ See Appendix Tables A7 and A8 for supporting data.

2/ From the Association of American Medical Colleges (1972-88, special tabulations generated annually from 1982-88). Figures for 1969 were estimated by the committee.

3/ Financial data from the University of Washington and Mayo Medical School were included for the first time in 1983.

## APPENDIX TABLE A10. Clinical R and D Expenditures + Professional Service Income in U.S. Medical Schools, by Type of Institutional Control, 1962-87 1/ (1972 $, thousands)

| Fiscal Year | Sum of Clinical R and D Expenditures + Professional Service Income | | | | | | Weighted Sum of Clinical R & D + Professional Service Income in Last 3 Years (1972 dollars) 2/ | | | Sum of Average Clinical R&D + Professional Service Income per School in Last 3 Years 2/ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Current Dollars | | | 1972 Dollars | | | | | | | | |
| | Total | Public | Private | Total | Public | Private | Total | Public | Private | Total | Public | Private |
| 1962 | 40,529 | 17,712 | 22,817 | 57,488 | 25,123 | 32,364 | | | | | | |
| 1963 | 52,374 | 22,934 | 29,440 | 73,148 | 32,031 | 41,117 | | | | | | |
| 1964 | 65,138 | 28,431 | 36,707 | 89,598 | 39,107 | 50,491 | 73,345 | 32,073 | 41,273 | 1,341 | 1,122 | 1,606 |
| 1965 | 78,729 | 35,232 | 43,496 | 105,961 | 47,419 | 58,542 | 89,576 | 39,416 | 50,160 | 1,558 | 1,331 | 1,818 |
| 1966 | 93,068 | 41,442 | 51,626 | 121,182 | 53,961 | 67,222 | 105,675 | 46,976 | 58,699 | 1,774 | 1,535 | 2,048 |
| 1967 | 114,745 | 52,183 | 62,562 | 145,247 | 66,055 | 79,193 | 123,393 | 55,349 | 68,044 | 1,938 | 1,684 | 2,233 |
| 1968 | 153,372 | 73,645 | 79,727 | 185,680 | 89,159 | 96,521 | 149,339 | 68,807 | 80,532 | 2,086 | 1,804 | 2,433 |
| 1969 | 187,625 | 86,800 | 100,825 | 216,407 | 100,115 | 116,292 | 183,254 | 86,122 | 97,132 | 2,393 | 2,048 | 2,842 |
| 1970 | 229,515 | 109,901 | 119,614 | 251,111 | 120,242 | 130,869 | 217,401 | 102,408 | 114,993 | 2,751 | 2,323 | 3,326 |
| 1971 | 265,835 | 130,583 | 135,253 | 276,912 | 136,024 | 140,888 | 248,885 | 119,156 | 129,729 | 2,989 | 2,510 | 3,655 |
| 1972 | 316,795 | 148,310 | 168,485 | 316,795 | 148,310 | 168,485 | 280,432 | 135,150 | 145,283 | 3,276 | 2,749 | 4,018 |
| 1973 | 365,337 | 177,798 | 187,539 | 345,309 | 168,051 | 177,258 | 313,953 | 150,174 | 163,779 | 3,664 | 3,108 | 4,432 |
| 1974 | 425,120 | 224,005 | 201,115 | 366,482 | 193,108 | 173,375 | 343,474 | 169,380 | 174,094 | 3,969 | 3,446 | 4,706 |
| 1975 | 611,300 | 310,716 | 300,584 | 480,582 | 244,274 | 236,308 | 389,714 | 199,635 | 190,079 | 4,380 | 3,803 | 5,245 |
| 1976 | 720,370 | 361,672 | 358,698 | 537,991 | 270,106 | 267,885 | 466,409 | 237,940 | 228,469 | 5,080 | 4,335 | 6,217 |
| 1977 | 933,457 | 439,352 | 494,105 | 658,755 | 310,058 | 348,698 | 553,830 | 273,636 | 280,194 | 5,844 | 4,842 | 7,361 |
| 1978 | 1,045,881 | 497,131 | 548,750 | 687,853 | 326,952 | 360,901 | 635,839 | 304,293 | 331,545 | 6,457 | 5,153 | 8,440 |
| 1979 | 1,181,901 | 583,589 | 598,311 | 714,312 | 352,707 | 361,605 | 687,193 | 329,167 | 358,026 | 6,782 | 5,379 | 8,927 |
| 1980 | 1,407,775 | 700,630 | 707,144 | 789,023 | 392,686 | 396,337 | 726,375 | 356,263 | 370,112 | 7,074 | 5,683 | 9,258 |
| 1981 | 1,587,905 | 791,697 | 796,209 | 813,726 | 405,707 | 408,019 | 776,521 | 385,947 | 390,574 | 7,456 | 6,002 | 9,805 |
| 1982 | 1,875,268 | 912,487 | 962,782 | 906,452 | 441,070 | 465,382 | 830,732 | 411,293 | 419,439 | 7,823 | 6,289 | 10,277 |
| 1983 3/ | 2,274,427 | 1,127,584 | 1,146,843 | 1,054,782 | 522,925 | 531,857 | 920,353 | 452,693 | 467,660 | 8,480 | 6,816 | 11,093 |
| 1984 | 2,579,908 | 1,284,359 | 1,295,549 | 1,154,683 | 574,837 | 579,846 | 1,042,675 | 515,440 | 527,235 | 9,422 | 7,606 | 12,290 |
| 1985 | 3,106,144 | 1,454,398 | 1,651,746 | 1,345,816 | 630,155 | 715,661 | 1,177,491 | 575,689 | 601,802 | 10,481 | 8,408 | 13,716 |
| 1986 | 3,343,244 | 1,704,489 | 1,638,755 | 1,410,413 | 719,072 | 691,341 | 1,314,182 | 638,555 | 675,627 | 11,524 | 9,251 | 15,001 |
| 1987 | 3,831,789 | 1,858,848 | 1,972,941 | 1,564,890 | 759,147 | 805,742 | 1,432,883 | 706,862 | 726,021 | 12,409 | 10,141 | 15,869 |

1/ See Appendix Tables A7, A8, and A9 for supporting data.

2/ Computed by the formula Di = 1/4(Si + 2Si-1 +Si-2), where Di = a weighted average; Si = sum of clinical R and D expenditures + professional service income in medical schools in year i.

3/ Financial data from the University of Washington and Mayo Medical School were included for the first time in 1983.

## APPENDIX TABLE A11 1. Sources of Revenue in U.S. Medical Schools, 1959-87 1/ (current $, millions)

| | Total Revenue | | | | | | | | | Number of Schools Reporting | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fiscal Year | All Schools | Public Schools | Private Schools | Federal Research | Other Federal | State/ Local Govt. | Tuition Revenue | Prof. Service Income | Other Revenue | All Schools | Public Schools | Private Schools |
| 1959 | 319 | | | | | | 24 | | | | | |
| 1960 | 371 | | | | | | 26 | 11 | | 87 | | |
| 1961 | 433 | 191 | 242 | | | | 28 | | | 87 | 44 | 43 |
| 1962 | 515 | 239 | 276 | | | | 30 | | | 87 | 44 | 43 |
| 1963 | 603 | 279 | 324 | | | | 32 | | | 87 | 44 | 43 |
| 1964 | 696 | 323 | 372 | | | | 35 | | | 87 | 44 | 43 |
| 1965 | 779 | 363 | 416 | | | | 39 | | | 87 | 44 | 43 |
| 1966 | 882 | 409 | 473 | | | | 41 | | | 88 | 44 | 44 |
| 1967 | 1,010 | 483 | 527 | | | | 44 | | | 88 | 44 | 44 |
| 1968 | 1,175 | 549 | 627 | | | | 48 | | | 89 | 45 | 44 |
| 1969 | 1,366 | 635 | 731 | | | | 52 | | | 92 | 47 | 45 |
| 1970 | 1,550 | 702 | 848 | | | | 56 | | | 93 | 48 | 45 |
| 1971 | 1,713 | 815 | 898 | 438 | 322 | 323 | 63 | 209 | 358 | 92 | 48 | 44 |
| 1972 | 1,945 | 916 | 1,030 | | | | 78 | | | 95 | 51 | 44 |
| 1973 | 2,181 | 1,070 | 1,111 | | | | 92 | | | 96 | 53 | 43 |
| 1974 | 2,524 | 1,321 | 1,204 | | | | 112 | | | 107 | 62 | 45 |
| 1975 | 3,046 | 1,634 | 1,412 | | | | 130 | | | 108 | 63 | 45 |
| 1976 | 3,389 | 1,819 | 1,570 | 823 | 398 | 808 | 156 | 609 | 595 | 111 | 65 | 46 |
| 1977 | 3,940 | 2,078 | 1,862 | | | | 194 | | | 112 | 65 | 47 |
| 1978 | 4,316 | 2,338 | 1,978 | | | | 231 | | | 112 | 66 | 46 |
| 1979 | 4,906 | 2,705 | 2,201 | | | | 265 | | | 112 | 66 | 46 |
| 1980 | 5,701 | 3,178 | 2,523 | | | | 308 | | | 119 | 73 | 46 |
| 1981 | 6,425 | 3,628 | 2,797 | 1,446 | 396 | 1,452 | 346 | 1,850 | 935 | 119 | 73 | 46 |
| 1982 | 7,216 | 3,995 | 3,221 | 1,578 | 415 | 1,617 | 413 | 2,140 | 1,054 | 121 | 74 | 47 |
| 1983 2/ | 8,179 | 4,531 | 3,647 | 1,655 | 415 | 1,784 | 482 | 2,626 | 1,216 | 124 | 75 | 49 |
| 1984 | 9,010 | 4,955 | 4,055 | 1,820 | 390 | 1,896 | 545 | 2,980 | 1,378 | 125 | 75 | 50 |
| 1985 | 10,078 | 5,513 | 4,565 | 2,067 | 403 | 2,089 | 582 | 3,315 | 1,622 | 125 | 75 | 50 |
| 1986 | 11,096 | 6,131 | 4,965 | 2,292 | 467 | 2,252 | 628 | 3,773 | 1,684 | 127 | 75 | 52 |
| 1987 | 12,589 | 6,561 | 6,028 | 2,500 | 482 | 2,335 | 669 | 4,737 | 1,866 | 127 | 74 | 53 |

1/ From the American Medical Association (1960-88). Numbers may not sum to totals due to rounding.

2/ Financial data from the University of Washington and Mayo Medical School were included for the first time in 1983. These two schools account for three percent of all revenue in U. S. medical schools.

## APPENDIX TABLE A11-2. Sources of Revenue in U.S. Medical Schools, 1959-87 1/ (1972 $, millions)

| | Total Revenue | | | | | | | | | Number of Schools Reporting | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fiscal Year | All Schools | Public Schools | Private Schools | Federal Research | Other Federal | State/ Local Govt | Tuition Revenue | Prof. Service Income | Other Revenue | All Schools | Public Schools | Private Schools | Implicit GNP Price Deflator 2/ (1972=100.00) |
| 1959 | 473 | | | | | | 36 | | | | | | 67.50 |
| 1960 | 540 | | | | | | 38 | 16 | | 87 | | | 68.70 |
| 1961 | 625 | 276 | 349 | | | | 40 | | | 87 | 44 | 43 | 69.30 |
| 1962 | 730 | 339 | 391 | | | | 43 | | | 87 | 44 | 43 | 70.50 |
| 1963 | 842 | 390 | 453 | | | | 45 | | | 87 | 44 | 43 | 71.60 |
| 1964 | 957 | 444 | 512 | | | | 48 | | | 87 | 44 | 43 | 72.70 |
| 1965 | 1,048 | 489 | 560 | | | | 52 | | | 87 | 44 | 43 | 74.30 |
| 1966 | 1,148 | 533 | 616 | | | | 53 | | | 88 | 44 | 44 | 76.80 |
| 1967 | 1,278 | 611 | 667 | | | | 56 | | | 88 | 44 | 44 | 79.00 |
| 1968 | 1,423 | 665 | 759 | | | | 58 | | | 89 | 45 | 44 | 82.60 |
| 1969 | 1,576 | 732 | 843 | | | | 60 | | | 92 | 47 | 45 | 86.70 |
| 1970 | 1,696 | 768 | 928 | | | | 61 | | | 93 | 48 | 45 | 91.40 |
| 1971 | 1,784 | 849 | 935 | 456 | 335 | 336 | 66 | 218 | 373 | 92 | 48 | 44 | 96.00 |
| 1972 | 1,945 | 916 | 1,030 | | | | 78 | | | 95 | 51 | 44 | 100.00 |
| 1973 | 2,061 | 1,011 | 1,050 | | | | 87 | | | 96 | 53 | 43 | 105.80 |
| 1974 | 2,176 | 1,139 | 1,038 | | | | 97 | | | 107 | 62 | 45 | 116.00 |
| 1975 | 2,395 | 1,285 | 1,110 | | | | 102 | | | 108 | 63 | 45 | 127.20 |
| 1976 | 2,531 | 1,358 | 1,173 | 615 | 297 | 603 | 117 | 455 | 444 | 111 | 65 | 46 | 133.90 |
| 1977 | 2,781 | 1,466 | 1,314 | | | | 137 | | | 112 | 65 | 47 | 141.70 |
| 1978 | 2,839 | 1,538 | 1,301 | | | | 152 | | | 112 | 66 | 46 | 152.05 |
| 1979 | 2,965 | 1,635 | 1,330 | | | | 160 | | | 112 | 66 | 46 | 165.46 |
| 1980 | 3,195 | 1,781 | 1,414 | | | | 173 | | | 119 | 73 | 46 | 178.42 |
| 1981 | 3,293 | 1,859 | 1,433 | 741 | 203 | 744 | 177 | 948 | 479 | 119 | 73 | 46 | 195.14 |
| 1982 | 3,488 | 1,931 | 1,557 | 763 | 201 | 782 | 200 | 1,034 | 509 | 121 | 74 | 47 | 206.88 |
| 1983 3/ | 3,793 | 2,101 | 1,691 | 768 | 192 | 827 | 224 | 1,218 | 564 | 124 | 75 | 49 | 215.63 |
| 1984 | 4,033 | 2,218 | 1,815 | 815 | 175 | 849 | 244 | 1,334 | 617 | 125 | 75 | 50 | 223.43 |
| 1985 | 4,367 | 2,389 | 1,978 | 896 | 175 | 905 | 252 | 1,436 | 703 | 125 | 75 | 50 | 230.80 |
| 1986 | 4,681 | 2,586 | 2,095 | 967 | 197 | 950 | 265 | 1,592 | 710 | 127 | 75 | 52 | 237.04 |
| 1987 | 5,141 | 2,679 | 2,462 | 1,021 | 197 | 954 | 273 | 1,935 | 762 | 127 | 74 | 53 | 244.86 |

1/ From the American Medical Association (1960-88). Numbers may not sum to totals due to rounding.

2/ From the U.S. Bureau of Census (1988a,b).

3/ Financial data from the University of Washington and Mayo Medical School, which account for 3% of all revenue in U.S. medical schools, were included for the first time in 1983.

## APPENDIX TABLE A12. Students in U.S. Dental Schools, by Type of Institutional Control, 1961-88 1/

| Fiscal Year | Predoctoral Enrollment |  |  | Graduates |  |  | Advanced Specialty Enrollment 2/ |  |  | Number of Schools |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | Total | Public | Private | Total | Public | Private | Total | Public | Private | Total | Public | Private |
| 1961 | 13,580 | 6,135 | 7,445 | 3,253 | 1,564 | 1,689 | n/a | n/a | n/a | 47 | n/a | n/a |
| 1962 | 13,513 | 6,121 | 7,392 | 3,290 | n/a | n/a | n/a | n/a | n/a | 47 | n/a | n/a |
| 1963 | 13,576 | 6,237 | 7,339 | 3,207 | n/a | n/a | n/a | n/a | n/a | 48 | n/a | n/a |
| 1964 | 13,691 | 6,333 | 7,358 | 3,233 | n/a | n/a | n/a | n/a | n/a | 48 | n/a | n/a |
| 1965 | 13,876 | 6,524 | 7,352 | 3,213 | n/a | n/a | n/a | n/a | n/a | 49 | n/a | n/a |
| 1966 | 14,020 | 6,601 | 7,419 | 3,181 | 1,602 | 1,579 | n/a | n/a | n/a | 49 | n/a | n/a |
| 1967 | 14,421 | 6,452 | 7,969 | 3,198 | n/a | n/a | n/a | n/a | n/a | 49 | n/a | n/a |
| 1968 | 14,955 | 7,108 | 7,847 | 3,360 | n/a | n/a | 1,374 | 653 | 721 | 50 | 25 | 25 |
| 1969 | 15,408 | 7,425 | 7,983 | 3,457 | n/a | n/a | 1,728 | 833 | 895 | 52 | 28 | 24 |
| 1970 | 16,008 | 7,430 | 8,578 | 3,433 | 1,759 | 1,674 | 1,851 | 859 | 992 | 53 | 20 | 24 |
| 1971 | 16,553 | 8,338 | 8,215 | 3,749 | 1,996 | 1,753 | 1,966 | 990 | 976 | 53 | 29 | 24 |
| 1972 | 17,305 | 8,865 | 8,440 | 3,775 | 1,924 | 1,851 | 2,171 | 1,112 | 1,059 | 52 | 29 | 23 |
| 1973 | 18,376 | 9,445 | 8,931 | 3,961 | 1,992 | 1,969 | 2,045 | 1,051 | 994 | 56 | 32 | 24 |
| 1974 | 19,369 | 10,217 | 9,152 | 4,230 | 2,147 | 2,083 | 2,024 | 1,068 | 956 | 58 | 34 | 24 |
| 1975 | 20,146 | 10,817 | 9,329 | 4,515 | 2,331 | 2,184 | 2,062 | 1,107 | 955 | 58 | 34 | 24 |
| 1976 | 20,767 | 11,413 | 9,354 | 4,969 | 2,463 | 2,506 | 2,022 | 1,111 | 911 | 59 | 35 | 24 |
| 1977 | 21,013 | 11,628 | 9,385 | 5,336 | 2,920 | 2,416 | 2,009 | 1,112 | 897 | 59 | 35 | 24 |
| 1978 | 21,510 | 12,004 | 9,506 | 5,177 | 2,796 | 2,381 | 2,054 | 1,146 | 908 | 59 | 35 | 24 |
| 1979 | 22,179 | 12,319 | 9,860 | 5,324 | 2,899 | 2,425 | 2,101 | 1,167 | 934 | 60 | 35 | 25 |
| 1980 | 22,482 | 12,523 | 9,959 | 5,424 | 2,964 | 2,460 | 2,127 | 1,185 | 942 | 60 | 35 | 25 |
| 1981 | 22,842 | 12,709 | 10,133 | 5,256 | 2,874 | 2,382 | 2,169 | 1,207 | 962 | 60 | 35 | 25 |
| 1982 | 22,621 | 12,559 | 10,062 | 5,550 | 3,004 | 2,546 | 2,188 | 1,299 | 889 | 60 | 35 | 25 |
| 1983 | 22,235 | 12,217 | 10,018 | 5,378 | 2,941 | 2,437 | 2,128 | 1,246 | 882 | 60 | 35 | 25 |
| 1984 | 21,428 | 11,577 | 9,851 | 5,756 | 3,207 | 2,529 | 2,159 | 1,239 | 920 | 60 | 35 | 25 |
| 1985 | 20,588 | 10,996 | 9,592 | 5,337 | 2,943 | 2,394 | 2,171 | 1,159 | 1,012 | 60 | 35 | 25 |
| 1986 | 19,563 | 10,455 | 9,108 | 5,353 | 2,863 | 2,490 | 2,311 | 1,234 | 1,077 | 60 | 35 | 25 |
| 1987 | 18,673 | 10,049 | 8,624 | 4,957 | 2,620 | 2,337 | 2,350 | 1,264 | 1,086 | 60 | 35 | 25 |
| 1988 | 17,885 | 9,674 | 8,211 | 4,717 | 2,496 | 2,221 | 2,436 | 1,318 | 1,118 | 59 | 35 | 24 |

1/ From the American Dental Association (1969-88).

2/ Public and private numbers were estimated from the total by using the same percentages as in predoctoral enrollments.

## APPENDIX TABLE A13. Faculty in U.S. Dental Schools, by Type of Institutional Control, 1969-87 1/

| | Full-Time | | | | | | | | | Part-Time (Full-time Equivalent) 2/ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All Schools | | | Public Schools | | | Private Schools | | | Clinical Departments | | |
| Fiscal Year | Total | Basic Sci Depts. | Clin. Depts. | Total | Basic Sci Depts. | Clin. Depts. | Total | Basic Sci Depts. | Clin. Depts. | All Schools | Public Schools | Private Schools |
| 1969 | 2,810 | 1,167 | 1,643 | 1,611 | 650 | 961 | 1,199 | 517 | 682 | 926.8 | 335.6 | 591.2 |
| 1970 | 3,329 | 1,389 | 1,940 | 1,982 | 821 | 1,161 | 1,347 | 568 | 779 | 1,060.2 | 422.2 | 638.0 |
| 1971 | 3,197 | 1,096 | 2,101 | 1,927 | 647 | 1,280 | 1,270 | 449 | 821 | 1,011.3 | 448.6 | 562.7 |
| 1972 | 3,351 | 1,088 | 2,263 | 2,041 | 627 | 1,414 | 1,310 | 461 | 849 | 1,129.7 | 507.4 | 622.3 |
| 1973 | 3,711 | 1,269 | 2,442 | 2,309 | 768 | 1,541 | 1,402 | 501 | 901 | 1,283.0 | 654.3 | 628.7 |
| 1974 | 3,927 | 1,255 | 2,672 | 2,473 | 764 | 1,709 | 1,454 | 491 | 963 | 1,355.3 | 624.4 | 730.8 |
| 1975 | 4,373 | 1,402 | 2,971 | 2,766 | 850 | 1,916 | 1,607 | 552 | 1,055 | 1,517.5 | 746.4 | 771.1 |
| 1976 | 4,885 | 1,646 | 3,239 | 3,149 | 1,050 | 2,099 | 1,736 | 596 | 1,140 | 1,341.8 | 664.1 | 677.7 |
| 1977 | 5,145 | 1,761 | 3,384 | 3,358 | 1,145 | 2,213 | 1,787 | 616 | 1,171 | 1,277.9 | 618.1 | 659.7 |
| 1978 | 5,108 | 1,696 | 3,412 | 3,314 | 1,096 | 2,218 | 1,794 | 600 | 1,194 | 1,318.9 | 648.2 | 670.7 |
| 1979 | 5,338 | 1,794 | 3,544 | 3,417 | 1,138 | 2,279 | 1,921 | 656 | 1,265 | 1,385.6 | 654.4 | 731.2 |
| 1980 | 5,521 | 1,856 | 3,665 | 3,472 | 1,174 | 2,298 | 2,049 | 682 | 1,367 | 1,429.1 | 684.5 | 744.6 |
| 1981 | 5,647 | 1,901 | 3,746 | 3,527 | 1,167 | 2,360 | 2,120 | 734 | 1,386 | 1,442.5 | 691.9 | 750.6 |
| 1982 | 5,706 | 1,917 | 3,789 | 3,561 | 1,152 | 2,409 | 2,145 | 765 | 1,380 | 1,391.2 | 694.5 | 696.7 |
| 1983 | 5,635 | 1,849 | 3,786 | 3,583 | 1,174 | 2,409 | 2,052 | 675 | 1,377 | 1,458.4 | 686.6 | 771.8 |
| 1984 | 5,478 | 1,790 | 3,688 | 3,441 | 1,100 | 2,341 | 2,037 | 690 | 1,347 | 1,392.7 | 661.3 | 731.4 |
| 1985 | 5,617 | 1,840 | 3,777 | 3,553 | 1,132 | 2,421 | 2,064 | 708 | 1,356 | 1,488.7 | 701.6 | 787.1 |
| 1986 | 5,423 | 1,795 | 3,628 | 3,485 | 1,125 | 2,360 | 1,937 | 669 | 1,268 | 1,438.5 | 697.7 | 740.8 |
| 1987 | 5,345 | 1,806 | 3,539 | 3,460 | 1,111 | 2,349 | 1,885 | 695 | 1,190 | 1,400.3 | 677.2 | 723.1 |

1/ From the American Dental Association (1969-88).

2/ Part-time faculty positions expressed as full-time equivalents are available for clinical departments only.

## APPENDIX TABLE A14-1. Research and Development Revenue in U.S. Dental Schools, by Type of Institutional Control, 1968-87 1/ ($ thousands)

| | R&D Revenue 2/ | | | | | | | | | Average R&D Revenue per School | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Current Dollars and Number of Schools Reporting | | | | | | 1972 Dollars 3/ | | | Current Dollars | | | 1972 Dollars 3/ | | |
| Fiscal Year | Total | No. | Public | No. | Private | No. | Total | Public | Private | Total | Public | Private | Total | Public | Private |
| 1968 | 14,019 | 46 | 8,667 | 23 | 5,352 | 23 | 16,972 | 10,493 | 6,479 | 305 | 377 | 233 | 369 | 456 | 282 |
| 1969 | 14,019 | 47 | 9,193 | 24 | 4,826 | 23 | 16,170 | 10,603 | 5,566 | 298 | 383 | 210 | 344 | 442 | 242 |
| 1970 | 14,869 | 47 | 8,443 | 24 | 6,426 | 23 | 16,268 | 9,237 | 7,031 | 316 | 352 | 279 | 346 | 385 | 306 |
| 1971 | 15,634 | 47 | 10,035 | 25 | 5,599 | 22 | 16,285 | 10,453 | 5,832 | 333 | 401 | 255 | 346 | 418 | 265 |
| 1972 | 17,155 | 48 | 12,153 | 27 | 5,002 | 21 | 17,155 | 12,153 | 5,002 | 357 | 450 | 238 | 357 | 450 | 238 |
| 1973 | 18,969 | 49 | 13,250 | 27 | 5,720 | 22 | 17,929 | 12,524 | 5,406 | 387 | 491 | 260 | 366 | 464 | 246 |
| 1974 | 20,718 | 50 | 14,787 | 28 | 5,931 | 22 | 17,860 | 12,747 | 5,113 | 414 | 528 | 270 | 357 | 455 | 232 |
| 1975 | 21,197 | 49 | 14,930 | 28 | 6,266 | 21 | 16,664 | 11,737 | 4,926 | 433 | 533 | 298 | 340 | 419 | 235 |
| 1976 | 23,975 | 50 | 16,135 | 28 | 7,840 | 22 | 17,905 | 12,050 | 5,855 | 480 | 576 | 356 | 358 | 430 | 266 |
| 1977 | 26,586 | 54 | 18,250 | 32 | 8,337 | 22 | 18,762 | 12,879 | 5,884 | 492 | 570 | 379 | 347 | 402 | 267 |
| 1978 | 28,500 | 56 | 19,565 | 33 | 8,935 | 23 | 18,744 | 12,867 | 5,876 | 509 | 593 | 388 | 335 | 390 | 255 |
| 1979 | 30,935 | 56 | 21,112 | 33 | 9,824 | 23 | 18,696 | 12,760 | 5,937 | 552 | 640 | 427 | 334 | 387 | 258 |
| 1980 | 33,960 | 57 | 23,645 | 34 | 10,315 | 23 | 19,034 | 13,252 | 5,781 | 596 | 695 | 448 | 334 | 390 | 251 |
| 1981 | 42,318 | 55 | 29,010 | 33 | 13,308 | 22 | 21,686 | 14,866 | 6,820 | 769 | 879 | 605 | 394 | 450 | 310 |
| 1982 | 46,706 | 57 | 31,804 | 34 | 14,902 | 23 | 22,576 | 15,373 | 7,203 | 819 | 935 | 648 | 396 | 452 | 313 |
| 1983 | 47,843 | 57 | 31,934 | 34 | 15,908 | 23 | 22,188 | 14,810 | 7,377 | 839 | 939 | 692 | 389 | 436 | 321 |
| 1984 | 54,110 | 57 | 36,861 | 34 | 17,249 | 23 | 24,218 | 16,498 | 7,720 | 949 | 1,084 | 750 | 425 | 485 | 336 |
| 1985 | 63,277 | 57 | 42,601 | 34 | 20,676 | 23 | 27,416 | 18,458 | 8,958 | 1,110 | 1,253 | 899 | 481 | 543 | 389 |
| 1986 | 68,970 | 57 | 47,551 | 35 | 21,419 | 22 | 29,096 | 20,060 | 9,036 | 1,210 | 1,359 | 974 | 510 | 573 | 411 |
| 1987 | 74,922 | 58 | 52,995 | 35 | 21,926 | 23 | 30,598 | 21,643 | 8,955 | 1,292 | 1,514 | 953 | 528 | 618 | 389 |

1/ From the American Dental Association (1969-88).

2/ Excludes indirect cost allowances.

3/ 1972 dollars were obtained by using the Implicit GNP Price Deflator (U.S. Bureau of the Census -- See Appendix Table A7).

## APPENDIX TABLE A14-2. Research and Development Expenditures in U.S. Dental Schools, by Type of Institutional Control, 1968-1987 ($ thousands)

| | Clinical R&D Expenditures | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Current Dollars and Number of Schools Reporting | | | | | | 1972 Dollars 2/ | | |
| Fiscal Year | Total | No. | Public | No. | Private | No. | Total | Public | Private |
| 1968 | n/a | | n/a | | n/a | | n/a | n/a | n/a |
| 1969 | n/a | | n/a | | n/a | | n/a | n/a | n/a |
| 1970 | n/a | | n/a | | n/a | | n/a | n/a | n/a |
| 1971 | n/a | | n/a | | n/a | | n/a | n/a | n/a |
| 1972 | n/a | | n/a | | n/a | | n/a | n/a | n/a |
| 1973 | n/a | | n/a | | n/a | | n/a | n/a | n/a |
| 1974 | 10,133 | 39 | 7,460 | 23 | 2,673 | 16 | 8,735 | 6,431 | 2,304 |
| 1975 | 10,512 | 43 | 8,157 | 27 | 2,354 | 15 | 8,264 | 6,413 | 1,851 |
| 1976 | 12,266 | 42 | 8,223 | 27 | 4,043 | 15 | 9,161 | 6,141 | 3,019 |
| 1977 | 11,369 | 45 | 8,451 | 28 | 2,918 | 17 | 8,023 | 5,964 | 2,059 |
| 1978 | 13,389 | 47 | 9,939 | 28 | 3,450 | 19 | 8,806 | 6,537 | 2,269 |
| 1979 | 12,602 | 42 | 9,893 | 27 | 2,710 | 15 | 7,616 | 5,979 | 1,638 |
| 1980 | 15,100 | 42 | 12,838 | 28 | 2,262 | 14 | 8,463 | 7,195 | 1,268 |
| 1981 | 19,025 | 41 | 15,176 | 27 | 3,849 | 14 | 9,749 | 7,777 | 1,972 |
| 1982 | 24,121 | 42 | 18,847 | 27 | 5,274 | 15 | 11,659 | 9,110 | 2,549 |
| 1983 | 22,328 | 43 | 17,442 | 27 | 4,886 | 16 | 10,355 | 8,089 | 2,266 |
| 1984 | 22,802 | 45 | 17,726 | 27 | 5,077 | 18 | 10,205 | 7,934 | 2,272 |
| 1985 | 25,467 | 45 | 19,765 | 28 | 5,702 | 17 | 11,034 | 8,564 | 2,471 |
| 1986 | 30,870 | 46 | 23,544 | 30 | 7,326 | 16 | 13,023 | 9,933 | 3,091 |
| 1987 | 33,723 | 48 | 26,161 | 30 | 7,562 | 18 | 13,772 | 10,684 | 3,088 |

1/ From the American Dental Association (1969-88).

2/ 1972 dollars were obtained by using the Implicit GNP Price Deflator (U.S. Bureau of the Census -- See Appendix Table A7.)

## APPENDIX TABLE A15. Dental Clinic Revenue in U.S. Dental Schools, by Type of Institutional Control, 1968-87 1/ ($, thousands)

| | Dental Clinic Revenue | | | | | | | | | Average Dental Clinical Revenue per School 2/ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Current Dollars and Number of Schools Reporting | | | | | | 1972 Dollars 3/ | | | Current Dollars | | | 1972 Dollars 3/ | | |
| Fiscal Year | Total | No. | Public | No. | Private | No. | Total | Public | Private | Total | Public | Private | Total | Public | Private |
| 1968 | 12,563 | 46 | 5,182 | 23 | 7,381 | 23 | 15,209 | 6,274 | 8,936 | 273 | 225 | 321 | 331 | 273 | 389 |
| 1969 | 14,004 | 47 | 5,871 | 24 | 8,133 | 23 | 16,152 | 6,772 | 9,381 | 298 | 245 | 354 | 344 | 282 | 408 |
| 1970 | 16,023 | 47 | 6,272 | 24 | 9,751 | 23 | 17,531 | 6,862 | 10,668 | 341 | 261 | 424 | 373 | 286 | 464 |
| 1971 | 18,490 | 47 | 7,521 | 25 | 10,969 | 22 | 19,260 | 7,834 | 11,426 | 393 | 301 | 499 | 410 | 313 | 519 |
| 1972 | 20,567 | 49 | 8,858 | 27 | 11,709 | 22 | 20,567 | 8,858 | 11,709 | 420 | 328 | 532 | 420 | 328 | 532 |
| 1973 | 21,787 | 48 | 9,481 | 25 | 12,306 | 23 | 20,593 | 8,961 | 11,631 | 454 | 379 | 535 | 429 | 358 | 506 |
| 1974 | 27,510 | 51 | 12,809 | 28 | 14,701 | 23 | 23,716 | 11,042 | 12,673 | 539 | 457 | 639 | 465 | 394 | 551 |
| 1975 | 32,193 | 50 | 14,724 | 27 | 17,469 | 23 | 25,309 | 11,575 | 13,733 | 644 | 545 | 760 | 506 | 429 | 597 |
| 1976 | 38,655 | 52 | 17,939 | 28 | 20,716 | 24 | 28,869 | 13,397 | 15,471 | 743 | 641 | 863 | 555 | 478 | 645 |
| 1977 | 43,989 | 55 | 21,010 | 31 | 22,979 | 24 | 31,044 | 14,827 | 16,217 | 800 | 678 | 957 | 564 | 478 | 676 |
| 1978 | 47,588 | 57 | 21,946 | 33 | 25,642 | 24 | 31,298 | 14,433 | 16,864 | 835 | 665 | 1,068 | 549 | 437 | 703 |
| 1979 | 57,979 | 59 | 29,065 | 35 | 28,914 | 24 | 35,041 | 17,566 | 17,475 | 983 | 830 | 1,205 | 594 | 502 | 728 |
| 1980 | 63,499 | 59 | 31,912 | 35 | 31,587 | 24 | 35,590 | 17,886 | 17,704 | 1,076 | 912 | 1,316 | 603 | 511 | 738 |
| 1981 | 74,141 | 58 | 38,321 | 34 | 35,820 | 24 | 37,994 | 19,638 | 18,356 | 1,278 | 1,127 | 1,493 | 655 | 578 | 765 |
| 1982 | 82,311 | 59 | 42,099 | 34 | 40,212 | 25 | 39,787 | 20,349 | 19,437 | 1,395 | 1,238 | 1,608 | 674 | 599 | 777 |
| 1983 | 94,272 | 60 | 49,524 | 35 | 44,748 | 25 | 43,719 | 22,967 | 20,752 | 1,571 | 1,415 | 1,790 | 729 | 656 | 830 |
| 1984 | 99,501 | 60 | 52,680 | 35 | 46,821 | 25 | 44,533 | 23,578 | 20,956 | 1,658 | 1,505 | 1,873 | 742 | 674 | 838 |
| 1985 | 104,941 | 59 | 56,219 | 35 | 48,722 | 24 | 45,468 | 24,358 | 21,110 | 1,779 | 1,606 | 2,030 | 771 | 696 | 880 |
| 1986 | 110,686 | 59 | 59,038 | 35 | 51,648 | 24 | 46,695 | 24,906 | 21,789 | 1,876 | 1,687 | 2,152 | 791 | 712 | 908 |
| 1987 | 118,641 | 59 | 64,491 | 35 | 54,150 | 24 | 48,453 | 26,338 | 22,115 | 2,011 | 1,843 | 2,256 | 821 | 753 | 921 |

1/ From the American Dental Association (1969-88).

2/ The average revenue per school is based on the number of schools reporting nonzero revenue. Where the number of schools reporting is less than the total number of schools, it cannot be determined with certainty whether "nonreporting" schools reported zero revenue or failed to report these data. See Appendix Table A18 for the number of schools reporting revenue from any source.

3/ 1972 dollars were obtained by using the Implicit GNP Price Deflator (U.S. Bureau of the Census--See Appendix Table A7).

## APPENDIX TABLE A16. Dental School Tuition Revenue, by Type of Institutional Control, 1968-87 1/ ($ thousands)

| | Dental School Tuition Revenue | | | | | | | | | Average Tuition Revenue per School | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Current Dollars and Number of Schools Reporting | | | | | | 1972 Dollars 3/ | | | Current Dollars | | | 1972 Dollars 3/ | | |
| Fiscal Year | Total | No. | Public | No. | Private | No. | Total | Public | Private | Total | Public | Private | Total | Public | Private |
| 1968 | 20,282 | 46 | 6,239 | 23 | 14,043 | 23 | 24,554 | 7,553 | 17,001 | 441 | 271 | 611 | 534 | 328 | 739 |
| 1969 | 22,994 | 47 | 6,622 | 24 | 16,372 | 23 | 26,521 | 7,638 | 18,884 | 489 | 276 | 712 | 564 | 318 | 821 |
| 1970 | 26,367 | 47 | 6,882 | 24 | 19,210 | 23 | 28,848 | 7,530 | 21,018 | 561 | 287 | 835 | 614 | 314 | 914 |
| 1971 | 28,793 | 47 | 7,836 | 24 | 20,957 | 23 | 29,993 | 8,163 | 21,830 | 613 | 327 | 911 | 638 | 340 | 949 |
| 1972 | 36,278 | 48 | 10,511 | 26 | 25,767 | 22 | 36,278 | 10,511 | 25,767 | 756 | 404 | 1,171 | 756 | 404 | 1,171 |
| 1973 | 41,129 | 49 | 12,003 | 26 | 29,125 | 23 | 38,874 | 11,345 | 27,528 | 839 | 462 | 1,266 | 793 | 436 | 1,197 |
| 1974 | 46,197 | 51 | 13,911 | 28 | 32,286 | 23 | 39,825 | 11,992 | 27,833 | 906 | 497 | 1,404 | 781 | 428 | 1,210 |
| 1975 | 51,648 | 51 | 15,209 | 28 | 36,440 | 23 | 40,604 | 11,957 | 28,648 | 1,013 | 543 | 1,584 | 796 | 427 | 1,246 |
| 1976 | 58,266 | 53 | 16,623 | 29 | 41,643 | 24 | 43,515 | 12,414 | 31,100 | 1,099 | 573 | 1,735 | 821 | 428 | 1,296 |
| 1977 | 67,818 | 56 | 19,872 | 32 | 47,946 | 24 | 47,860 | 14,024 | 33,836 | 1,211 | 621 | 1,998 | 855 | 438 | 1,410 |
| 1978 | 78,930 | 57 | 23,256 | 33 | 55,664 | 24 | 51,911 | 15,302 | 36,609 | 1,385 | 705 | 2,319 | 911 | 464 | 1,525 |
| 1979 | 94,394 | 59 | 26,860 | 35 | 67,534 | 24 | 57,049 | 16,234 | 40,816 | 1,600 | 767 | 2,814 | 967 | 464 | 1,701 |
| 1980 | 108,341 | 59 | 29,069 | 35 | 79,273 | 24 | 60,722 | 16,292 | 44,431 | 1,836 | 831 | 3,303 | 1,029 | 465 | 1,851 |
| 1981 | 115,668 | 59 | 32,716 | 35 | 82,897 | 24 | 59,274 | 16,765 | 42,481 | 1,960 | 935 | 3,454 | 1,005 | 479 | 1,770 |
| 1982 | 147,308 | 60 | 39,690 | 35 | 107,618 | 25 | 71,205 | 19,185 | 52,020 | 2,455 | 1,134 | 4,305 | 1,187 | 548 | 2,081 |
| 1983 | 164,990 | 60 | 46,018 | 35 | 118,972 | 25 | 76,515 | 21,341 | 55,174 | 2,750 | 1,315 | 4,759 | 1,275 | 610 | 2,207 |
| 1984 | 172,088 | 60 | 48,161 | 35 | 123,927 | 25 | 77,021 | 21,555 | 55,466 | 2,868 | 1,376 | 4,957 | 1,284 | 616 | 2,219 |
| 1985 | 179,621 | 59 | 50,278 | 35 | 129,343 | 24 | 77,825 | 21,784 | 56,041 | 3,044 | 1,437 | 5,389 | 1,319 | 622 | 2,335 |
| 1986 | 186,452 | 59 | 53,690 | 35 | 132,761 | 24 | 78,658 | 22,650 | 56,008 | 3,160 | 1,534 | 5,532 | 1,333 | 647 | 2,334 |
| 1987 | 191,934 | 59 | 55,751 | 35 | 136,183 | 24 | 78,385 | 22,769 | 55,617 | 3,253 | 1,593 | 5,674 | 1,329 | 651 | 2,317 |

1/ From the American Dental Association (1969-88).

2/ The average revenue per school is based on the number of schools reporting nonzero revenue. Where the number of schools reporting is less than the total number of schools, it cannot be determined with certainty whether "nonreporting" schools reported zero revenue or failed to report these data. See Appendix Table A18 for the number of schools reporting revenue from any source.

3/ 1972 dollars were obtained by using the Implicit GNP Price Deflator (U.S. Bureau of the Census--See Appendix Table A7).

## APPENDIX TABLE A17. Revenue from State and Local Governments in U.S. Dental Schools, by Type of Institutional Control, 1968-87 1/ ($ thousands)

| | Revenue from State/Local Governments 2/ | | | | | | | | | Average State/Local Govt. Revenue per School 3/ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Current Dollars and Number of Schools Reporting | | | | | | 1972 Dollars 4/ | | | Current Dollars | | | 1972 Dollars 4/ | | |
| Fiscal Year | Total | No | Public | No | Private | No | Total | Public | Private | Total | Public | Private | Total | Public | Private |
| 1968 | 27,130 | 23 | 27,130 | 23 | - | | 32,845 | 32,845 | 0 | 590 | 1,180 | 0 | 714 | 1,428 | 0 |
| 1969 | 32,980 | 24 | 32,980 | 24 | - | | 38,039 | 38,039 | 0 | 702 | 1,374 | 0 | 809 | 1,585 | 0 |
| 1970 | 40,488 | 24 | 40,488 | 24 | - | | 44,298 | 44,298 | 0 | 861 | 1,687 | 0 | 942 | 1,846 | 0 |
| 1971 | 34,545 | 24 | 33,418 | 20 | 1,127 | 4 | 35,984 | 34,810 | 1,174 | 720 | 1,337 | 49 | 750 | 1,392 | 51 |
| 1972 | 68,207 | 40 | 62,084 | 27 | 6,123 | 13 | 68,207 | 62,084 | 6,123 | 1,392 | 2,299 | 278 | 1,392 | 2,299 | 278 |
| 1973 | 85,874 | 40 | 78,321 | 27 | 7,553 | 13 | 81,166 | 74,027 | 7,139 | 1,718 | 2,901 | 328 | 1,623 | 2,742 | 310 |
| 1974 | 99,708 | 43 | 87,857 | 28 | 11,851 | 15 | 85,955 | 75,739 | 10,216 | 1,955 | 3,138 | 515 | 1,685 | 2,705 | 444 |
| 1975 | 117,562 | 43 | 102,656 | 28 | 14,906 | 15 | 92,423 | 80,720 | 11,719 | 2,306 | 3,667 | 648 | 1,812 | 2,883 | 510 |
| 1976 | 142,735 | 46 | 122,968 | 29 | 19,767 | 17 | 106,598 | 91,836 | 14,763 | 2,693 | 4,240 | 824 | 2,011 | 3,167 | 615 |
| 1977 | 175,927 | 51 | 151,564 | 32 | 24,363 | 19 | 124,155 | 106,961 | 17,193 | 3,142 | 4,736 | 1,015 | 2,217 | 3,343 | 716 |
| 1978 | 205,974 | 52 | 177,737 | 33 | 28,237 | 19 | 135,465 | 115,894 | 18,571 | 3,614 | 5,386 | 1,177 | 2,377 | 3,542 | 774 |
| 1979 | 225,762 | 54 | 195,132 | 35 | 30,630 | 19 | 136,445 | 117,933 | 18,512 | 3,827 | 5,575 | 1,276 | 2,313 | 3,370 | 771 |
| 1980 | 253,432 | 53 | 217,464 | 35 | 35,968 | 18 | 142,042 | 122,612 | 20,159 | 4,296 | 6,213 | 1,499 | 2,422 | 3,503 | 845 |
| 1981 | 280,176 | 59 | 243,719 | 35 | 36,457 | 24 | 143,577 | 125,901 | 18,682 | 4,749 | 6,963 | 1,519 | 2,453 | 3,597 | 785 |
| 1982 | 306,571 | 54 | 268,196 | 35 | 38,375 | 19 | 148,188 | 129,469 | 18,549 | 5,110 | 7,663 | 1,535 | 2,467 | 3,699 | 741 |
| 1983 | 318,326 | 54 | 278,307 | 35 | 40,019 | 19 | 147,626 | 129,067 | 18,559 | 5,305 | 7,952 | 1,601 | 2,460 | 3,688 | 742 |
| 1984 | 332,256 | 52 | 288,446 | 35 | 43,810 | 17 | 148,707 | 129,224 | 19,608 | 6,390 | 8,241 | 2,577 | 2,863 | 3,692 | 1,155 |
| 1985 | 351,068 | 51 | 306,793 | 35 | 44,275 | 16 | 152,109 | 132,841 | 19,183 | 6,884 | 8,766 | 2,767 | 2,981 | 3,795 | 1,198 |
| 1986 | 368,671 | 52 | 328,408 | 35 | 40,263 | 17 | 155,531 | 138,588 | 16,986 | 7,090 | 9,383 | 2,368 | 2,992 | 3,960 | 999 |
| 1987 | 382,359 | 51 | 342,277 | 35 | 40,082 | 16 | 156,154 | 139,649 | 16,369 | 7,497 | 9,779 | 2,505 | 3,059 | 3,990 | 1,022 |

1/ From the American Dental Association (1969-88).

2/ Excludes sponsored research and education programs, and indirect cost allowances.

3/ The average revenue per school is based on the number of schools reporting nonzero revenue. Where the number of schools reporting is less than the total number of schools, it cannot be determined with certainty whether "nonreporting" schools reported zero revenue or failed to report these data. See Appendix Table A18 for the number of schools reporting revenue from any source.

3/ 1972 dollars were obtained by using the Implicit GNP Price Deflator (U.S. Bureau of the Census--See Appendix Table A7).

## APPENDIX TABLE A18. Total Revenue in U.S. Dental Schools, by Type of Institutional Control, 1968-87 1/ ($ thousands)

| | Total Dental School Revenue | | | | | | | | | Total Revenue per School | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Current Dollars and Number of Schools Reporting | | | | | | 1972 Dollars 2/ | | | Current Dollars | | | 1972 Dollars 2/ | | |
| Fiscal Year | Total | No. | Public | No. | Private | No. | Total | Public | Private | Total | Public | Private | Total | Public | Private |
| 1968 | 108,649 | 46 | 65,164 | 23 | 43,485 | 23 | 131,536 | 78,891 | 52,645 | 2,362 | 2,833 | 1,891 | 2,859 | 3,430 | 2,289 |
| 1969 | 127,076 | 47 | 76,126 | 24 | 50,950 | 23 | 146,570 | 87,804 | 58,766 | 2,704 | 3,172 | 2,215 | 3,119 | 3,658 | 2,555 |
| 1970 3/ | 141,960 | 47 | 85,290 | 24 | 56,670 | 23 | 155,317 | 93,315 | 62,002 | 3,020 | 3,554 | 2,464 | 3,305 | 3,888 | 2,696 |
| 1971 | 167,141 | 48 | 94,453 | 25 | 72,688 | 23 | 174,105 | 98,389 | 75,717 | 3,482 | 3,778 | 3,160 | 3,627 | 3,936 | 3,292 |
| 1972 | 195,625 | 49 | 116,467 | 27 | 79,157 | 22 | 195,625 | 116,467 | 79,157 | 3,992 | 4,314 | 3,598 | 3,992 | 4,314 | 3,598 |
| 1973 | 238,210 | 50 | 147,124 | 27 | 91,086 | 23 | 225,151 | 139,059 | 86,093 | 4,764 | 5,449 | 3,960 | 4,503 | 5,150 | 3,743 |
| 1974 | 270,705 | 51 | 170,496 | 28 | 100,209 | 23 | 233,366 | 146,979 | 86,387 | 5,308 | 6,089 | 4,357 | 4,576 | 5,249 | 3,756 |
| 1975 | 310,388 | 51 | 191,518 | 28 | 118,869 | 23 | 244,016 | 150,564 | 93,450 | 6,086 | 6,840 | 5,168 | 4,785 | 5,377 | 4,063 |
| 1976 | 347,804 | 53 | 216,421 | 29 | 131,383 | 24 | 259,749 | 161,629 | 98,120 | 6,562 | 7,463 | 5,474 | 4,901 | 5,573 | 4,088 |
| 1977 | 394,938 | 56 | 251,414 | 32 | 143,524 | 24 | 278,714 | 177,427 | 101,287 | 7,052 | 7,857 | 5,980 | 4,977 | 5,545 | 4,220 |
| 1978 | 441,075 | 57 | 281,661 | 33 | 159,414 | 24 | 290,085 | 185,242 | 104,843 | 7,738 | 8,535 | 6,642 | 5,089 | 5,613 | 4,368 |
| 1979 | 489,932 | 59 | 311,643 | 35 | 178,289 | 24 | 296,103 | 188,349 | 107,754 | 8,304 | 8,904 | 7,429 | 5,019 | 5,381 | 4,490 |
| 1980 | 541,413 | 59 | 341,357 | 35 | 200,057 | 24 | 303,449 | 191,322 | 112,127 | 9,176 | 9,753 | 8,336 | 5,143 | 5,466 | 4,672 |
| 1981 | 607,113 | 59 | 380,828 | 35 | 226,284 | 24 | 311,117 | 195,156 | 115,960 | 10,290 | 10,881 | 9,429 | 5,273 | 5,576 | 4,832 |
| 1982 | 665,168 | 60 | 415,991 | 35 | 249,177 | 25 | 321,524 | 201,078 | 120,445 | 11,086 | 11,885 | 9,967 | 5,359 | 5,745 | 4,818 |
| 1983 | 699,811 | 60 | 434,584 | 35 | 265,227 | 25 | 324,543 | 201,542 | 123,001 | 11,664 | 12,417 | 10,609 | 5,409 | 5,758 | 4,920 |
| 1984 | 735,193 | 60 | 458,527 | 35 | 276,666 | 25 | 329,048 | 205,222 | 123,827 | 12,253 | 13,101 | 11,067 | 5,484 | 5,863 | 4,953 |
| 1985 | 778,376 | 59 | 489,515 | 35 | 288,861 | 24 | 337,251 | 212,095 | 125,156 | 13,193 | 13,986 | 12,036 | 5,716 | 6,060 | 5,215 |
| 1986 | 816,300 | 59 | 525,897 | 35 | 290,403 | 24 | 344,372 | 221,860 | 122,512 | 13,836 | 15,026 | 12,100 | 5,837 | 6,339 | 5,105 |
| 1987 | 860,537 | 59 | 555,875 | 35 | 304,662 | 24 | 351,440 | 227,017 | 124,423 | 14,585 | 15,882 | 12,694 | 5,957 | 6,486 | 5,184 |

1/ From the American Dental Association (1969-88).

2/ 1972 dollars were obtained by using the Implicit GNP Price Deflator (U.S. Bureau of the Census -- See Appendix Table A7).

3/ Public figures for 1970 are interpolated.

## APPENDIX TABLE A19. Full-Time Budgeted Vacancies on U.S. Dental School Faculties, by Type of Institutional Control, 1969-87 1/

| | All Departments | | | Basic Science Depts. | | | Clinical Science Depts. | | |
|---|---|---|---|---|---|---|---|---|---|
| Fiscal Year | Total | Public | Private | Total | Public | Private | Total | Public | Private |
| 1969 | 293 | 223 | 70 | 110 | 79 | 31 | 183 | 144 | 39 |
| 1970 | 201 | 101 | 100 | 60 | 23 | 37 | 141 | 78 | 63 |
| 1971 | 167 | 102 | 65 | 51 | 26 | 25 | 116 | 76 | 40 |
| 1972 | 160 | 102 | 58 | 42 | 22 | 20 | 118 | 80 | 38 |
| 1973 | 268 | 189 | 79 | 79 | 51 | 28 | 189 | 138 | 51 |
| 1974 | 278 | 176 | 102 | 76 | 50 | 26 | 202 | 126 | 76 |
| 1975 | 224 | 147 | 77 | 45 | 33 | 12 | 179 | 114 | 65 |
| 1976 | 203 | 132 | 71 | 43 | 24 | 19 | 160 | 108 | 52 |
| 1977 | 179 | 116 | 63 | 37 | 24 | 13 | 142 | 92 | 50 |
| 1978 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1979 | 193 | 105 | 88 | 49 | 19 | 30 | 144 | 86 | 58 |
| 1980 | 191 | 113 | 78 | 39 | 19 | 20 | 152 | 94 | 58 |
| 1981 | 161 | 94 | 67 | 34 | 20 | 14 | 127 | 74 | 53 |
| 1982 | 174 | 87 | 87 | 37 | 25 | 12 | 137 | 62 | 75 |
| 1983 | 192 | 120 | 72 | 49 | 36 | 13 | 143 | 84 | 59 |
| 1984 | 238 | 158 | 80 | 50 | 33 | 17 | 188 | 125 | 63 |
| 1985 | 211 | 150 | 61 | 62 | 50 | 12 | 149 | 100 | 49 |
| 1986 | 248 | 207 | 41 | 73 | 61 | 12 | 175 | 146 | 29 |
| 1987 | 246 | 178 | 68 | 64 | 50 | 14 | 182 | 128 | 54 |

1/ From the American Dental Association (1968-88).

## APPENDIX TABLE A20. NIH Trainees and Fellows in Clinical Dental Research, 1977-86 1/

| Fiscal Year | Total |  |  | Trainees |  |  | Fellows |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  | Total | Predoc | Postdoc | Total | Predoc | Postdoc | Total | Predoc | Postdoc |
| 1977 | 112 | 12 | 100 | 61 | 9 | 52 | 51 | 3 | 48 |
| 1978 | 172 | 20 | 152 | 123 | 20 | 103 | 49 | 0 | 49 |
| 1979 | 176 | 28 | 148 | 128 | 28 | 100 | 48 | 0 | 48 |
| 1980 | 171 | 23 | 148 | 116 | 23 | 93 | 55 | 0 | 55 |
| 1981 | 170 | 18 | 152 | 107 | 18 | 89 | 63 | 0 | 63 |
| 1982 | 160 | 20 | 140 | 112 | 20 | 92 | 48 | 0 | 48 |
| 1983 | 160 | 21 | 139 | 121 | 21 | 100 | 39 | 0 | 39 |
| 1984 | 167 | 21 | 146 | 133 | 21 | 112 | 34 | 0 | 34 |
| 1985 | 171 | 19 | 152 | 131 | 19 | 112 | 40 | 0 | 40 |
| 1986 | 137 | 19 | 118 | 117 | 19 | 98 | 20 | 0 | 20 |

1/Figures were obtained from the NIH Trainee and Fellow File, and represent persons receiving NRSA awards.

## APPENDIX TABLE A21. Number of New Faculty and Percentage of New Faculty Among Full-Time Faculty in U.S. Medical Schools, by Year and Degree Type, 1970-88 1/

| | New Faculty | | | Percent New Faculty | | |
|---|---|---|---|---|---|---|
| Year | Total | MD | PhD | Total | MD | PhD |
| 1970 | 3017 | 1732 | 889 | 10.14 | 9.33 | 11.75 |
| 1971 | 3628 | 2183 | 998 | 11.29 | 10.96 | 11.99 |
| 1972 | 3731 | 2171 | 1085 | 10.80 | 10.18 | 11.89 |
| 1973 | 4232 | 2680 | 1086 | 11.62 | 11.96 | 11.10 |
| 1974 | 4159 | 2514 | 1111 | 10.69 | 10.42 | 10.55 |
| 1975 | 4369 | 2791 | 1110 | 10.55 | 10.88 | 9.84 |
| 1976 | 4338 | 2878 | 1041 | 9.91 | 10.54 | 8.74 |
| 1977 | 4620 | 3072 | 1128 | 10.11 | 10.68 | 9.09 |
| 1978 | 4435 | 2882 | 1139 | 9.30 | 9.55 | 8.78 |
| 1979 | 4651 | 3061 | 1213 | 9.34 | 9.68 | 8.90 |
| 1980 | 4428 | 2978 | 1100 | 8.49 | 8.96 | 7.69 |
| 1981 | 3990 | 2730 | 972 | 7.36 | 7.87 | 6.56 |
| 1982 | 3892 | 2620 | 1014 | 7.04 | 7.36 | 6.69 |
| 1983 | 3715 | 2652 | 863 | 6.61 | 7.29 | 5.59 |
| 1984 | 3805 | 2581 | 1006 | 6.66 | 6.93 | 6.45 |
| 1985 | 3579 | 2428 | 903 | 6.15 | 6.36 | 5.71 |
| 1986 | 3694 | 2571 | 882 | 6.23 | 6.57 | 5.48 |
| 1987 | 3377 | 2344 | 785 | 5.58 | 5.85 | 4.78 |
| 1988 | 2891 | 2006 | 669 | 4.72 | 4.93 | 4.04 |

1/ Data derived from the AAMC Faculty Roster and published by NIH/OSPL/DPE/PPRB, 1989

## APPENDIX TABLE A22. Number and Percentage of New Faculty in U.S. Medical Schools Who Have Had Postdoctoral Research Training, by Department and Degree Type, 1982-1988 1/

All Departments

| Year | MD Total | MD Post-docs | Percent | PhD Total | PhD Post-docs | Percent |
|---|---|---|---|---|---|---|
| 1982 | 2,620 | 1,174 | 44.8 | 1,014 | 744 | 73.4 |
| 1983 | 2,652 | 1,171 | 44.2 | 863 | 633 | 73.3 |
| 1984 | 2,581 | 1,145 | 44.4 | 1,006 | 735 | 73.1 |
| 1985 | 2,428 | 1,037 | 42.7 | 903 | 652 | 72.2 |
| 1986 | 2,571 | 1,047 | 40.7 | 882 | 655 | 74.3 |
| 1987 | 2,344 | 934 | 39.8 | 785 | 554 | 70.6 |
| 1988 | 2,006 | 740 | 36.9 | 669 | 459 | 68.6 |
| Average | | | 41.9 | | | 72.2 |

Basic Science Departments

| Year | MD Total | MD Post-docs | Percent | PhD Total | PhD Post-docs | Percent |
|---|---|---|---|---|---|---|
| 1982 | 124 | 70 | 56.5 | 446 | 392 | 87.9 |
| 1983 | 106 | 51 | 48.1 | 378 | 339 | 89.7 |
| 1984 | 119 | 59 | 49.6 | 430 | 375 | 87.2 |
| 1985 | 113 | 57 | 50.4 | 392 | 346 | 88.3 |
| 1986 | 105 | 53 | 50.5 | 400 | 357 | 89.3 |
| 1987 | 109 | 55 | 50.5 | 330 | 287 | 87.0 |
| 1988 | 90 | 54 | 60.0 | 270 | 234 | 86.7 |
| Average | | | 52.2 | | | 88.0 |

Clinical Science Departments

| Year | MD Total | MD Post-docs | Percent | PhD Total | PhD Post-docs | Percent |
|---|---|---|---|---|---|---|
| 1982 | 2,486 | 1,100 | 44.2 | 514 | 331 | 64.4 |
| 1983 | 2,539 | 1,121 | 44.2 | 455 | 282 | 62.0 |
| 1984 | 2,455 | 1,084 | 44.2 | 543 | 346 | 63.7 |
| 1985 | 2,301 | 973 | 42.3 | 469 | 294 | 62.7 |
| 1986 | 2,454 | 990 | 40.3 | 457 | 283 | 61.9 |
| 1987 | 2,220 | 874 | 39.4 | 419 | 249 | 59.4 |
| 1988 | 1,906 | 683 | 35.8 | 370 | 214 | 57.8 |
| Average | | | 41.5 | | | 61.7 |

1/ Data derived from the AAMC Faculty Roster and published by NIH/OSPL/DPE/PPRB, 1989

## APPENDIX TABLE A23. Composition of Total Faculty and New Faculty in Basic Science Departments of U.S. Medical Schools, by Degree, 1970-88 1/

| | All Faculty | | | | | New Faculty Only | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | MD | | PhD | | | MD | | PhD | |
| Year | Total | Number | Percent | Number | Percent | Total | Number | Percent | Number | Percent |
| 1970 | 7,757 | 2,657 | 34.3 | 4,592 | 59.2 | 637 | 188 | 29.5 | 409 | 64.2 |
| 1971 | 8,293 | 2,740 | 33.0 | 5,009 | 60.4 | 684 | 173 | 25.3 | 466 | 68.1 |
| 1972 | 8,810 | 2,835 | 32.2 | 5,408 | 61.4 | 742 | 191 | 25.7 | 504 | 67.9 |
| 1973 | 9,199 | 2,865 | 31.1 | 5,732 | 62.3 | 838 | 199 | 23.7 | 578 | 69.0 |
| 1974 | 9,661 | 2,927 | 30.3 | 6,134 | 63.5 | 822 | 210 | 25.5 | 574 | 69.8 |
| 1975 | 10,088 | 2,965 | 29.4 | 6,506 | 64.5 | 777 | 169 | 21.8 | 561 | 72.2 |
| 1976 | 10,391 | 2,993 | 28.8 | 6,783 | 65.3 | 760 | 189 | 24.9 | 530 | 69.7 |
| 1977 | 10,634 | 2,997 | 28.2 | 7,030 | 66.1 | 747 | 186 | 24.9 | 520 | 69.6 |
| 1978 | 10,923 | 3,006 | 27.5 | 7,310 | 66.9 | 791 | 192 | 24.3 | 550 | 69.5 |
| 1979 | 11,229 | 3,002 | 26.7 | 7,598 | 67.7 | 734 | 172 | 23.4 | 522 | 71.1 |
| 1980 | 11,524 | 3,017 | 26.2 | 7,890 | 68.5 | 732 | 147 | 20.1 | 545 | 74.5 |
| 1981 | 11,715 | 3,012 | 25.7 | 8,075 | 68.9 | 708 | 150 | 21.2 | 518 | 73.2 |
| 1982 | 11,801 | 2,978 | 25.2 | 8,208 | 69.6 | 607 | 147 | 24.2 | 432 | 71.2 |
| 1983 | 11,804 | 2,943 | 24.9 | 8,310 | 70.4 | 591 | 124 | 21.0 | 446 | 75.5 |
| 1984 | 11,788 | 2,901 | 24.6 | 8,342 | 70.8 | 507 | 106 | 20.9 | 378 | 74.6 |
| 1985 | 11,874 | 2,889 | 24.3 | 8,457 | 71.2 | 565 | 119 | 21.1 | 430 | 76.1 |
| 1986 | 11,925 | 2,885 | 24.2 | 8,526 | 71.5 | 528 | 113 | 21.4 | 392 | 74.2 |
| 1987 | 12,048 | 2,884 | 23.9 | 8,670 | 72.0 | 522 | 105 | 20.1 | 400 | 76.6 |
| 1988 | 12,009 | 2,866 | 23.9 | 8,663 | 72.1 | 462 | 109 | 23.6 | 330 | 71.4 |

1/ Data derived from the AAMC Faculty Roster and published by NIH/OSPL/DPE/PPRB, 1989

## APPENDIX TABLE A24. Composition of Total Faculty and New Faculty in Clinical Departments of U.S. Medical Schools, by Degree, 1970-88 1/

| | All Faculty | | | | | New Faculty Only | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | MD | | PhD | | | MD | | PhD | |
| Year | Total | Number | Percent | Number | Percent | Total | Number | Percent | Number | Percent |
| 1970 | 20,405 | 15,542 | 76.2 | 2,562 | 12.6 | 1,844 | 1,345 | 72.9 | 302 | 16.4 |
| 1971 | 22,064 | 16,804 | 76.2 | 2,829 | 12.8 | 2,126 | 1,550 | 72.9 | 347 | 16.3 |
| 1972 | 23,808 | 18,113 | 76.1 | 3,151 | 13.2 | 2,664 | 1,979 | 74.3 | 410 | 15.4 |
| 1973 | 25,217 | 19,156 | 76.0 | 3,421 | 13.6 | 2,659 | 1,963 | 73.8 | 425 | 16.0 |
| 1974 | 27,135 | 20,806 | 76.7 | 3,715 | 13.7 | 3,159 | 2,459 | 77.8 | 440 | 13.9 |
| 1975 | 29,052 | 22,306 | 76.8 | 4,017 | 13.8 | 3,096 | 2,329 | 75.2 | 470 | 15.2 |
| 1976 | 31,032 | 23,919 | 77.1 | 4,317 | 13.9 | 3,347 | 2,579 | 77.1 | 494 | 14.8 |
| 1977 | 32,660 | 25,352 | 77.6 | 4,536 | 13.9 | 3,366 | 2,673 | 79.4 | 447 | 13.3 |
| 1978 | 34,409 | 26,758 | 77.8 | 4,827 | 14.0 | 3,626 | 2,871 | 79.2 | 508 | 14.0 |
| 1979 | 36,256 | 28,211 | 77.8 | 5,159 | 14.2 | 3,502 | 2,701 | 77.1 | 545 | 15.6 |
| 1980 | 38,281 | 29,808 | 77.9 | 5,520 | 14.4 | 3,730 | 2,902 | 77.8 | 597 | 16.0 |
| 1981 | 40,126 | 31,278 | 77.9 | 5,831 | 14.5 | 3,562 | 2,815 | 79.0 | 529 | 14.9 |
| 1982 | 41,203 | 32,190 | 78.1 | 6,028 | 14.6 | 3,231 | 2,572 | 79.6 | 481 | 14.9 |
| 1983 | 42,179 | 32,995 | 78.2 | 6,213 | 14.7 | 3,186 | 2,486 | 78.0 | 514 | 16.1 |
| 1984 | 43,205 | 33,974 | 78.6 | 6,374 | 14.8 | 3,125 | 2,539 | 81.2 | 455 | 14.6 |
| 1985 | 44,344 | 34,927 | 78.8 | 6,581 | 14.8 | 3,152 | 2,455 | 77.9 | 543 | 17.2 |
| 1986 | 45,397 | 35,843 | 79.0 | 6,790 | 15.0 | 2,939 | 2,301 | 78.3 | 469 | 16.0 |
| 1987 | 46,544 | 36,801 | 79.1 | 6,987 | 15.0 | 3,081 | 2,454 | 79.6 | 457 | 14.8 |
| 1988 | 47,380 | 37,467 | 79.1 | 7,123 | 15.0 | 2,823 | 2,220 | 78.6 | 419 | 14.8 |

1/ Data derived from the AAMC Faculty Roster and published by NIH/OSPL/DPE/PPRB, 1989

## APPENDIX TABLE A25. Number of Faculty Who Had Returned to Full-Time Positions at U.S. Medical Schools After Leaving Academic Medicine in 1970 For One or More Years 1/

| Returned By | Total 2/ (N=1850) | MD (N=1212) | PhD (N=350) |
|---|---|---|---|
| 1972 | 5.5 | 6 | 7.1 |
| 1973 | 9 | 9.7 | 10.9 |
| 1974 | 10.6 | 11.5 | 13.7 |
| 1975 | 11.4 | 12.7 | 13.1 |
| 1976 | 12 | 13.2 | 15.1 |
| 1977 | 12.8 | 14.2 | 16 |
| 1978 | 12.8 | 14.1 | 16.6 |
| 1979 | 12.9 | 14.7 | 16 |
| 1980 | 12.4 | 14.1 | 15.7 |
| 1981 | 12.3 | 14 | 15.4 |
| 1982 | 11.9 | 13.6 | 14.9 |
| 1983 | 11.8 | 13.7 | 14.3 |
| 1984 | 11.5 | 13.3 | 14 |
| 1985 | 11.5 | 13.1 | 14.3 |
| 1986 | 11.5 | 13.4 | 13.4 |
| 1987 | 11.3 | 13.2 | 13.1 |
| 1988 | 10.9 | 13 | 11.7 |

1/ Data derived from the AAMC Faculty Roster and published by NIH/OSPL/DPE/PPRB, 1989

2/ Total includes faculty drop-outs who held degrees other than MD or PhD

## APPENDIX TABLE B1. Biomedical Science Enrollments in Colleges and Universities, by Type of Institutional Control, 1960-87 1/

| | | | | | | | Graduate Enrollment | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total Undergraduate and Graduate Enrollment | | | Estimated Undergraduate Enrollment 2/ | | | Total Medical , Dental and Biomed. Sci. Graduate | | | Medical and Dental 3/ | | | Biomedical Science Graduate 4/ | | |
| Fiscal Year | Total | Public | Private | Total | Public | Private | Total | Public | Private | Total | Public | Private | Total | Public | Private |
| 1960 | 197,419 | n/a | n/a | 143,037 | n/a | n/a | 54,382 | n/a | n/a | 43,665 | n/a | n/a | 10,717 | 6,516 | 4,201 |
| 1961 | 217,711 | n/a | n/a | 161,236 | n/a | n/a | 56,475 | n/a | n/a | 44,268 | n/a | n/a | 12,207 | 7,768 | 4,439 |
| 1962 | 241,945 | n/a | n/a | 183,890 | n/a | n/a | 58,055 | n/a | n/a | 44,590 | n/a | n/a | 13,465 | 8,841 | 4,624 |
| 1963 | 265,534 | n/a | n/a | 205,839 | n/a | n/a | 59,695 | n/a | n/a | 44,814 | n/a | n/a | 14,881 | 9,827 | 5,054 |
| 1964 | 286,169 | n/a | n/a | 223,002 | n/a | n/a | 63,167 | n/a | n/a | 45,692 | n/a | n/a | 17,475 | n/a | n/a |
| 1965 | 279,371 | n/a | n/a | 213,042 | n/a | n/a | 66,329 | n/a | n/a | 45,982 | n/a | n/a | 20,347 | n/a | n/a |
| 1966 | 301,921 | n/a | n/a | 231,977 | n/a | n/a | 69,944 | n/a | n/a | 46,512 | n/a | n/a | 23,432 | n/a | n/a |
| 1967 | 311,635 | n/a | n/a | 239,725 | 161,555 | 78,170 | 71,910 | n/a | n/a | 47,563 | n/a | n/a | 24,347 | n/a | n/a |
| 1968 | 327,940 | n/a | n/a | 251,170 | 173,606 | 77,564 | 76,770 | n/a | n/a | 49,273 | n/a | n/a | 27,497 | n/a | n/a |
| 1969 | 358,166 | n/a | n/a | 279,160 | 200,825 | 78,335 | 79,006 | n/a | n/a | 50,510 | n/a | n/a | 28,496 | n/a | n/a |
| 1970 | 364,382 | n/a | n/a | 299,553 | 220,073 | 79,480 | 84,829 | n/a | n/a | 53,986 | n/a | n/a | 30,843 | n/a | n/a |
| 1971 | 414,650 | n/a | n/a | 325,018 | 242,058 | 82,960 | 89,632 | n/a | n/a | 57,029 | n/a | n/a | 32,603 | n/a | n/a |
| 1972 | 438,671 | 318,900 | 119,771 | 343,587 | 259,492 | 84,095 | 95,084 | 59,408 | 35,676 | 60,881 | 34,369 | 26,512 | 34,203 | 25,039 | 9,164 |
| 1973 | 480,055 | 350,954 | 129,101 | 379,268 | 288,109 | 91,159 | 100,787 | 62,845 | 37,942 | 65,899 | 37,390 | 28,509 | 34,888 | 25,455 | 9,433 |
| 1974 | 510,603 | 376,292 | 134,311 | 404,881 | 309,900 | 94,981 | 105,722 | 66,392 | 39,330 | 69,611 | 40,021 | 29,590 | 36,111 | 26,371 | 9,740 |
| 1975 | 537,075 | 399,593 | 137,482 | 424,539 | 328,697 | 95,842 | 112,536 | 70,896 | 41,640 | 74,222 | 42,731 | 31,491 | 38,314 | 28,165 | 10,149 |
| 1976 | 556,279 | 417,056 | 139,223 | 439,946 | 343,184 | 96,762 | 116,333 | 73,872 | 42,461 | 77,011 | 44,949 | 32,062 | 39,322 | 28,923 | 10,399 |
| 1977 | 556,064 | n/a | n/a | 437,525 | n/a | n/a | 118,539 | 75,623 | 42,916 | 79,279 | 46,657 | 32,622 | 39,260 | 28,966 | 10,294 |
| 1978 | 546,542 | n/a | n/a | 420,686 | n/a | n/a | 125,856 | 80,095 | 45,761 | 81,934 | 48,730 | 33,204 | 43,922 | 31,365 | 12,557 |
| 1979 | 517,123 | n/a | n/a | 388,833 | n/a | n/a | 128,290 | 81,698 | 46,592 | 84,761 | 50,681 | 34,080 | 43,529 | 31,017 | 12,512 |
| 1980 | 507,798 | n/a | n/a | 378,161 | n/a | n/a | 129,637 | 82,498 | 47,139 | 86,502 | 51,830 | 34,672 | 43,135 | 30,668 | 12,467 |
| 1981 | 501,907 | n/a | n/a | 371,272 | n/a | n/a | 130,635 | 83,477 | 47,158 | 88,254 | 53,194 | 35,060 | 42,381 | 30,283 | 12,098 |
| 1982 | 498,006 | n/a | n/a | 367,128 | n/a | n/a | 130,878 | 83,484 | 47,394 | 89,105 | 53,693 | 35,412 | 41,773 | 29,791 | 11,982 |
| 1983 | 502,999 | n/a | n/a | 372,687 | n/a | n/a | 130,312 | 82,580 | 47,732 | 89,121 | 53,609 | 35,512 | 41,191 | 28,971 | 12,220 |
| 1984 | 505,437 | n/a | n/a | 375,269 | n/a | n/a | 130,168 | 81,820 | 48,348 | 88,865 | 52,372 | 36,493 | 41,303 | 29,448 | 11,855 |
| 1985 | n/a | n/a | n/a | n/a | n/a | n/a | 130,106 | 81,492 | 48,614 | 87,674 | 51,580 | 36,094 | 42,432 | 29,912 | 12,520 |
| 1986 | n/a | n/a | n/a | n/a | n/a | n/a | 129,407 | 81,077 | 48,330 | 86,170 | 50,614 | 35,556 | 43,237 | 30,463 | 12,774 |
| 1987 | n/a | n/a | n/a | n/a | n/a | n/a | 129,086 | 80,966 | 48,120 | 84,591 | 49,593 | 34,998 | 44,495 | 31,373 | 13,122 |

(See footnotes on the following page)

## APPENDIX TABLE B1 Continued

1/ Biomedical science undergraduate, graduate, and dental student enrollments for Temple University and the University of Pittsburg were counted as public; medical school enrollments were counted as private. The Association of American Medical Colleges, which provided the medical school data, was the only data source which considered those universities to be privately controlled.

2/ Estimated by the formula $U_i = (A_{i+2}/B_{i+2})C_i$, where $U_i$ = biomedical science undergraduate enrollment in year $i$; $A_{i+2}$ = biomedical science baccalaureate degrees awarded in year $i+2$ excluding health professions); $B_{i+2}$ = total baccalaureate degrees awarded in year $i+2$; $C_i$ = total undergraduate degree-credit enrollment in year $i$ (excluding first professional). Public and private estimates were based on enrollment ratios. See Appendix Tables B3 and B4 for supporting data.

3/ Medical school enrollment figures were obtained from the Association of American Medical Colleges (1972-88, special annual tabulations) and the American Medical Association (1960-88). Dental school enrollment figures were obtained from the American Dental Association (1969-88).

4/ Figures for 1960-77 were obtained from the U.S. Department of Education (1959-79). Figures for 1978-87 were obtained from the National Science Foundation (1973-88a) except for the 1979 figure which was interpolated. Because of differences in taxonomy, NSF numbers for 1978-87 total biomedical science graduate students may be slightly higher than numbers that would have been obtained from the Department of Education had data been collected for those years. For the year 1977, NSF reported 42,495 graduate students enrolled in the biomedical sciences; in comparison, the Department of Education reported a somewhat lower figure of 39,260 (as shown in this table).

## APPENDIX TABLE B2. First-Year Graduate Enrollment in the Biomedical Sciences, 1960-87

| Fiscal Year | Total First-Year Enrollment 1/ | First-Year Full-Time Enrollment 2/ |
|---|---|---|
| 1960 | 5,370 | n/a |
| 1961 | 6,025 | n/a |
| 1962 | 6,642 | n/a |
| 1963 | 7,137 | n/a |
| 1964 | 8,542 | n/a |
| 1965 | 10,430 | n/a |
| 1966 | 12,034 | n/a |
| 1967 | 12,511 | n/a |
| 1968 | 13,301 | n/a |
| 1969 | 13,343 | n/a |
| 1970 | 14,835 | n/a |
| 1971 | 15,845 | n/a |
| 1972 | 16,722 | n/a |
| 1973 | 17,511 | n/a |
| 1974 | 17,538 | n/a |
| 1975 | 18,876 | 9,382 |
| 1976 | 18,756 | 9,918 |
| 1977 | 18,073 | 9,763 |
| 1978 | n/a | 9,612 |
| 1979 | n/a | 8,836 |
| 1980 | n/a | 8,348 |
| 1981 | n/a | 8,279 |
| 1982 | n/a | 8,105 |
| 1983 | n/a | 8,043 |
| 1984 | n/a | 8,320 |
| 1985 | n/a | 8,451 |
| 1986 | n/a | 8,529 |
| 1987 | n/a | 8,609 |

1/ From the U.S. Department of Education (1959-79).

2/ From the National Science Foundation (1973-88a). Represents doctorate-granting institutions only.

## APPENDIX TABLE B3. Biomedical Science Degrees Awarded in Colleges and Universities, by Type of Institutional Control, and Postdoctoral Appointments in All Employment Sectors, 1960-1987

| | B.A. Degrees Awarded 1/ (excluding first professional) | | | Ph.D. Degrees Awarded 2/ | | | Postdoctoral Appointments 3/ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Academic 4/ | | | |
| Fiscal Year | Total | Public | Private | Total | Public | Private | Total | Total | Public | Private | Nonacademic |
| 1960 | n/a | n/a | n/a | 1,096 | n/a | n/a | | | | | |
| 1961 | 15,588 | n/a | n/a | 1,136 | n/a | n/a | | | | | |
| 1962 | 16,424 | n/a | n/a | 1,272 | n/a | n/a | | | | | |
| 1963 | 18,704 | n/a | n/a | 1,341 | n/a | n/a | | | | | |
| 1964 | 22,207 | n/a | n/a | 1,552 | n/a | n/a | | | | | |
| 1965 | 24,612 | n/a | n/a | 1,753 | n/a | n/a | | | | | |
| 1966 | 26,336 | n/a | n/a | 1,961 | n/a | n/a | | | | | |
| 1967 | 28,157 | n/a | n/a | 2,181 | n/a | n/a | | | | | |
| 1968 | 31,221 | n/a | n/a | 2,545 | n/a | n/a | | | | | |
| 1969 | 34,795 | 20,338 | 14,457 | 2,854 | n/a | n/a | | | | | |
| 1970 | 36.868 | 22,382 | 14,486 | 3,171 | n/a | n/a | | | | | |
| 1971 | 40,000 | 24,611 | 15,389 | 3,482 | n/a | n/a | | | | | |
| 1972 | 42,000 | 26,208 | 15,792 | 3,460 | 2,385 | 1,075 | | | | | |
| 1973 | 45,000 | 28,236 | 16,764 | 3,520 | 2,466 | 1,054 | 3,607 | 2,883 | 1,636 | 1,247 | 724 |
| 1974 | 47,434 | 29,881 | 17,553 | 3,417 | 2,327 | 1,090 | n/a | n/a | n/a | n/a | n/a |
| 1975 | 50,493 | 31,841 | 18,652 | 3,515 | 2,401 | 1,114 | 5,369 | 4,361 | 2,530 | 1,831 | 1,008 |
| 1976 | 52,642 | 33,244 | 19,398 | 3,578 | 2,447 | 1,131 | n/a | n/a | n/a | n/a | n/a |
| 1977 | 51,783 | 32,789 | 18,994 | 3,465 | 2,386 | 1,079 | 6,312 | 5,211 | 2,836 | 2,375 | 1,101 |
| 1978 | 49,701 | 30,968 | 18,733 | 3,518 | 2,440 | 1,078 | n/a | n/a | n/a | n/a | n/a |
| 1979 | 47,717 | 29,241 | 18,476 | 3,644 | 2,466 | 1,178 | 7,268 | 5,974 | 3,543 | 2,431 | 1,294 |
| 1980 | 45,106 | 27,279 | 17,827 | 3,823 | 2,632 | 1,191 | n/a | n/a | n/a | n/a | n/a |
| 1981 | 42,297 | 25,380 | 16,917 | 3,846 | 2,599 | 1,247 | 8,026 | 6,740 | 4,064 | 2,676 | 1,286 |
| 1982 | 40,750 | 24,167 | 16,583 | 3,960 | 2,673 | 1,287 | n/a | n/a | n/a | n/a | n/a |
| 1983 | 38,322 | n/a | n/a | 3,788 | 2,621 | 1,166 | 7,827 | 6,208 | 3,287 | 2,921 | 1,619 |
| 1984 | 37,115 | n/a | n/a | 3,902 | 2,665 | 1,236 | n/a | n/a | n/a | n/a | n/a |
| 1985 | 37,364 | n/a | n/a | 3,787 | 2,569 | 1,217 | 8,364 | n/a | n/a | n/a | n/a |
| 1986 | 37,597 | n/a | n/a | 3,864 | 2,621 | 1,240 | n/a | n/a | n/a | n/a | n/a |
| 1987 | 37,284 | n/a | n/a | 3,969 | 2,650 | 1,318 | 8,172 | n/a | n/a | n/a | n/a |

1/ Figures for 1961-68 were obtained from the U.S. Department of Education (1948-81); those for 1969-82 from the U.S. Department of Education (1948-88); those for 1983-87 from the U.S. Department of Education (1974-87). Figures for 1971-73 were estimated by the committee in order to remove the distortion produced in the series by the change in the survey taxonomy in 1971. Health professions are not included.

2/ From the National Research Council's Doctorate Records File (1958-88). Foreign nationals who received doctorates from U.S. institutions are included.

3/ Figures are based on the most recent data available from the National Research Council's Survey of Doctorate Recipients (1973-88). Foreign nationals who received doctorates from U.S. institutions are included.

4/ Public and private figures were adjusted by the committee to include a small number of individuals for whom control of institution could not be determined.

## APPENDIX TABLE B4. Total Undergraduate Degree-Credit Enrollment, Total B.A. Degrees Awarded, and Ratio of Biomedical Science B.A.s to Total B.A.s, by Type of Institutional Control, 1960-87

| | Total Undergraduate Degree-Credit Enrollment (thousands) 1/ | | | | | | | | | Ratio of Biomed. Sci. B.A.'s to Total B.A.s 5/ |
|---|---|---|---|---|---|---|---|---|---|---|
| | Including First Professional 2/ | | | Excluding First Professional 3/ | | | B.A. Degrees Awarded 4/ (excluding first professional) | | | |
| Fiscal Year | Total | Public | Private | Total | Public | Private | Total | Public | Private | Total |
| 1960 | 3,402 | n/a | n/a | 3,334 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1961 | 3,610 | n/a | n/a | 3,538 | n/a | n/a | 365,337 | n/a | n/a | 0.0427 |
| 1962 | 3,891 | n/a | n/a | 3,813 | n/a | n/a | 382,822 | n/a | n/a | 0.0429 |
| 1963 | 4,207 | n/a | n/a | 4,123 | n/a | n/a | 410,421 | n/a | n/a | 0.0456 |
| 1964 | 4,529 | n/a | n/a | 4,438 | n/a | n/a | 460,467 | n/a | n/a | 0.0482 |
| 1965 | 4,342 | 2,802 | 1,541 | 4,255 | n/a | n/a | 492,984 | n/a | n/a | 0.0499 |
| 1966 | 4,829 | 3,184 | 1,645 | 4,732 | n/a | n/a | 524,117 | n/a | n/a | 0.0502 |
| 1967 | 5,160 | 3,451 | 1,709 | 5,057 | 3,408 | 1,649 | 562,369 | n/a | n/a | 0.0501 |
| 1968 | 5,557 | 3,810 | 1,747 | 5,437 | 3,758 | 1,679 | 636,863 | n/a | n/a | 0.0490 |
| 1969 | 6,043 | 4,308 | 1,735 | 5,905 | 4,248 | 1,657 | 734,002 | 466,133 | 267,869 | 0.0474 |
| 1970 | 6,529 | 4,749 | 1,780 | 6,377 | 4,685 | 1,692 | 798,070 | 523,442 | 274,628 | 0.0462 |
| 1971 | 6,889 | 5,076 | 1,813 | 6,719 | 5,004 | 1,715 | 846,110 | 562,345 | 283,765 | 0.0473 |
| 1972 | 7,104 | 5,302 | 1,802 | 6,913 | 5,221 | 1,692 | 894,110 | 604,471 | 289,639 | 0.0470 |
| 1973 | 7,199 | 5,401 | 1,799 | 6,998 | 5,316 | 1,682 | 930,272 | 636,378 | 293,894 | 0.0484 |
| 1974 | 7,396 | 5,589 | 1,807 | 7,187 | 5,501 | 1,686 | 954,376 | 657,455 | 296,921 | 0.0497 |
| 1975 | 7,833 | 5,986 | 1,847 | 7,610 | 5,892 | 1,718 | 931,663 | 640,524 | 291,139 | 0.0542 |
| 1976 | 8,468 | 6,520 | 1,948 | 8,234 | 6,423 | 1,811 | 934,443 | 640,799 | 293,644 | 0.0563 |
| 1977 4/ | 8,786 | n/a | n/a | 8,540 | n/a | n/a | 928,228 | 635,909 | 292,319 | 0.0558 |
| 1978 | 9,022 | n/a | n/a | 8,769 | n/a | n/a | 930,201 | 633,183 | 297,018 | 0.0534 |
| 1979 | 8,963 | n/a | n/a | 8,705 | n/a | n/a | 931,340 | 627,084 | 304,256 | 0.0512 |
| 1980 | 9,211 | n/a | n/a | 8,946 | n/a | n/a | 940,251 | 629,338 | 310,913 | 0.0480 |
| 1981 | 9,672 | n/a | n/a | 9,393 | n/a | n/a | 946,877 | 632,168 | 314,709 | 0.0447 |
| 1982 | 9,914 | n/a | n/a | 9,638 | n/a | n/a | 964,043 | 641,751 | 322,292 | 0.0423 |
| 1983 | 10,050 | n/a | n/a | 9,770 | n/a | n/a | 969,510 | n/a | n/a | 0.0395 |
| 1984 | 10,140 | n/a | n/a | 9,860 | n/a | n/a | 974,309 | n/a | n/a | 0.0381 |
| 1985 | 9,928 | n/a | n/a | 9,647 | n/a | n/a | 979,477 | n/a | n/a | 0.0381 |
| 1986 | 9,838 | n/a | n/a | 9,561 | n/a | n/a | 987,823 | n/a | n/a | 0.0381 |
| 1987 | 10,168 | n/a | n/a | 9,894 | n/a | n/a | 991,264 | 659,260 | 332,004 | n/a |

1/ The Department of Education last collected data on "degree-credit" enrollment in FY 1976; beginning in FY 1977, the survey collected data on "unclassified undergraduates", defined as non-degree-seeking students. Beginning in FY 1977, undergraduate degree-credit enrollment is defined as total undergraduate enrollment excluding unclassified undergraduates.

2/ Figures for 1960-64 were obtained from the U.S. Department of Education (1961-84), those for 1965-75 from the U.S. Department of Education, (1973-82), and the one for 1976 from the U.S. Department of Education (1974-87). Figures for 1977-87 are from the U.S. Department of Education (1961-88).

3/ Figures for 1960-66 were estimated at 98% of total undergraduate degree-credit enrollment (including first professional). Those for 1967-76 were obtained by subtracting first professional enrollment from total degree-credit undergraduate enrollment (including first professional). First professional enrollment data for 1967-76 were obtained from the U.S. Department of Education (1959-79), data for 1977-87 from the U.S. Department of Education (1961-88).

4/ Figures for 1961-68 were obtained from the U.S. Department of Education (1948-81), those for 1969-82 from the U.S. Department of Education (1948-88); those for 1983-87 from the U.S. Department of Education (1974-87).

5/ See Appendix Table B3 for number of baccalaureate degrees awarded in the biomedical sciences.

## APPENDIX TABLE B5. Ph.D.s Employed in the Biomedical Sciences, 1973-87 1/

| Fiscal Year | Total Labor Force | Total Academia (excluding postdocs.) | Postdoc. Appts. | Business | Gov't. | FFRDC Labs | Hospitals/ Clinics | Non-Profit | Self-Employed | Other | Unemployed and Seeking |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1973 | 43,688 | 25,471 | 3,607 | 5,369 | 4,338 | 1,031 | 1,431 | 1,293 | 518 | 186 | 444 |
| 1974 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1975 | 50,620 | 28,332 | 5,369 | 6,662 | 4,517 | 994 | 1,948 | 1,232 | 840 | 194 | 532 |
| 1976 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1977 | 55,031 | 30,384 | 6,312 | 6,893 | 4,568 | 1,040 | 2,297 | 1,543 | 862 | 335 | 797 |
| 1978 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1979 | 62,332 | 33,566 | 7,268 | 8,455 | 5,080 | 1,079 | 2,726 | 1,858 | 1,185 | 439 | 676 |
| 1980 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1981 | 68,806 | 36,482 | 8,026 | 9,928 | 5,398 | 1,236 | 2,799 | 2,088 | 1,857 | 225 | 767 |
| 1982 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1983 | 71,423 | 36,963 | 7,827 | 11,819 | 5,988 | 661 | 2,946 | 2,102 | 1,910 | 255 | 952 |
| 1984 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1985 | 79,515 | 41,032 | 8,364 | 13,706 | 6,479 | 783 | 3,307 | 2,460 | 2,254 | 302 | 828 |
| 1986 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1987 | 85,339 | 43,025 | 8,172 | 15,928 | 7,049 | 909 | 3,629 | 2,651 | 2,634 | 437 | 905 |

1/ Figures are based on the most recent data available from the National Research Council's Survey of Doctorate Recipients (1973-88). Foreign nationals who received doctorates from U.S. institutions are included.

## APPENDIX TABLE B6. National Expenditures for Health-Related R and D, 1960-89 1/ ($ millions)

| | Current Dollars | | | | 1972 Dollars | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Fiscal Year | Total | Federal | Private Industry | Other | Total | Federal | Private Industry | Other | Implicit Price Deflator 2/ (1972 = 100.0) |
| 1960 | 886 | 448 | 253 | 185 | 1,290 | 652 | 368 | 269 | 68.70 |
| 1961 | 1,087 | 574 | 312 | 201 | 1,569 | 828 | 450 | 290 | 69.30 |
| 1962 | 1,333 | 782 | 336 | 215 | 1,891 | 1,109 | 477 | 305 | 70.50 |
| 1963 | 1,526 | 919 | 375 | 232 | 2,131 | 1,284 | 524 | 324 | 71.60 |
| 1964 | 1,698 | 1,049 | 400 | 249 | 2,336 | 1,443 | 550 | 343 | 72.70 |
| 1965 | 1,890 | 1,174 | 450 | 266 | 2,544 | 1,580 | 606 | 358 | 74.30 |
| 1966 | 2,111 | 1,316 | 510 | 285 | 2,749 | 1,714 | 664 | 371 | 76.80 |
| 1967 | 2,345 | 1,459 | 580 | 306 | 2,968 | 1,847 | 734 | 387 | 79.00 |
| 1968 | 2,568 | 1,582 | 661 | 325 | 3,109 | 1,915 | 800 | 393 | 82.60 |
| 1969 | 2,785 | 1,674 | 754 | 357 | 3,212 | 1,931 | 870 | 412 | 86.70 |
| 1970 | 2,847 | 1,667 | 795 | 385 | 3,115 | 1,824 | 870 | 421 | 91.40 |
| 1971 | 3,168 | 1,877 | 860 | 431 | 3,300 | 1,955 | 896 | 449 | 96.00 |
| 1972 | 3,536 | 2,147 | 934 | 455 | 3,536 | 2,147 | 934 | 455 | 100.00 |
| 1973 | 3,750 | 2,225 | 1,048 | 477 | 3,544 | 2,103 | 991 | 451 | 105.80 |
| 1974 | 4,443 | 2,754 | 1,183 | 506 | 3,830 | 2,374 | 1,020 | 436 | 116.00 |
| 1975 | 4,701 | 2,832 | 1,319 | 550 | 3,696 | 2,226 | 1,037 | 432 | 127.20 |
| 1976 | 5,107 | 3,059 | 1,469 | 579 | 3,814 | 2,285 | 1,097 | 432 | 133.90 |
| 1977 | 5,568 | 3,396 | 1,614 | 558 | 3,929 | 2,397 | 1,139 | 394 | 141.70 |
| 1978 | 6,262 | 3,811 | 1,800 | 651 | 4,118 | 2,506 | 1,184 | 428 | 152.05 |
| 1979 | 7,133 | 4,321 | 2,093 | 719 | 4,311 | 2,612 | 1,265 | 435 | 165.46 |
| 1980 | 7,935 | 4,723 | 2,459 | 754 | 4,447 | 2,647 | 1,378 | 423 | 178.42 |
| 1981 | 8,703 | 4,848 | 2,998 | 856 | 4,460 | 2,484 | 1,536 | 439 | 195.14 |
| 1982 | 9,483 | 4,970 | 3,561 | 952 | 4,584 | 2,402 | 1,721 | 460 | 206.88 |
| 1983 | 10,634 | 5,399 | 4,145 | 1,089 | 4,932 | 2,504 | 1,922 | 505 | 215.63 |
| 1984 | 12,014 | 6,087 | 4,643 | 1,284 | 5,377 | 2,724 | 2,078 | 575 | 223.43 |
| 1985 | 13,408 | 6,791 | 5,244 | 1,374 | 5,809 | 2,942 | 2,272 | 595 | 230.80 |
| 1986 | 14,801 | 6,895 | 6,166 | 1,740 | 6,244 | 2,909 | 2,601 | 734 | 237.04 |
| 1987 | 16,827 | 7,827 | 7,130 | 1,871 | 6,872 | 3,197 | 2,912 | 764 | 244.86 |
| 1988 (est.) | 18,729 | 8,454 | 8,260 | 2,016 | 7,462 | 3,368 | 3,291 | 803 | 250.98 |
| 1989 (proj.) | 20,575 | 9,207 | 9,259 | 2,109 | n/a | n/a | n/a | n/a | n/a |

1/ From NIH Data Book (1966-88, and pre-publication). Items may not sum to totals due to rounding.

2/ From the U.S. Bureau of the Census (1988a,b).

## APPENDIX TABLE B7. NIH Research Grant Expenditures, 1965-88 1/ ($ millions)

| | Total NIH Research Grant Expenditures | | NIH Research Grant Expenditures in U.S. Colleges and Universities | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Current Dollars | | | 1972 Dollars 2/ | | |
| Fiscal Year | Current Dollars | 1972 Dollars 2/ | Total | Public | Private | Total | Public | Private |
| 1965 | 492.1 | 662.3 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1966 | 551.2 | 717.7 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1967 | 618.4 | 782.8 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1968 | 647.0 | 783.3 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1969 | 649.1 | 748.7 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1970 | 624.3 | 683.0 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1971 | 699.7 | 728.9 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1972 | 826.5 | 826.5 | 676.7 | 339.7 | 337.0 | 676.7 | 676.7 | 676.7 |
| 1973 | 838.5 | 792.5 | 680.7 | 332.2 | 348.5 | 643.4 | 314.0 | 329.4 |
| 1974 | 1,100.8 | 949.0 | 885.0 | 448.7 | 436.3 | 762.9 | 386.8 | 376.1 |
| 1975 | 1,148.0 | 902.5 | 927.3 | 469.1 | 458.2 | 729.0 | 368.8 | 360.2 |
| 1976 | 1,275.8 | 952.8 | 1,025.4 | 516.1 | 509.3 | 765.8 | 385.4 | 380.4 |
| 1977 | 1,435.7 | 1,013.2 | 1,148.8 | 577.5 | 571.3 | 810.7 | 407.6 | 403.2 |
| 1978 | 1,638.0 | 1,077.3 | 1,322.4 | 668.4 | 654.0 | 869.7 | 439.6 | 430.1 |
| 1979 | 1,951.7 | 1,179.6 | 1,579.7 | 808.6 | 771.1 | 954.7 | 488.7 | 466.0 |
| 1980 | 2,161.1 | 1,211.2 | 1,742.6 | 893.2 | 849.5 | 976.7 | 500.6 | 476.1 |
| 1981 | 2,331.4 | 1,194.7 | 1,882.6 | 963.7 | 918.9 | 964.7 | 493.9 | 470.9 |
| 1982 | 2,407.7 | 1,163.8 | 1,937.8 | 991.2 | 946.6 | 936.7 | 479.1 | 457.6 |
| 1983 | 2,702.3 | 1,253.2 | 2,175.7 | 1,097.4 | 1,078.3 | 1,009.0 | 508.9 | 500.1 |
| 1984 | 3,087.0 | 1,381.6 | 2,470.1 | 1,254.9 | 1,217.9 | 1,105.5 | 561.7 | 545.1 |
| 1985 | 3,591.3 | 1,556.0 | 2,870.2 | n/a | n/a | 1,243.6 | n/a | n/a |
| 1986 | 3,739.1 | 1,577.4 | 2,974.9 | n/a | n/a | 1,255.0 | n/a | n/a |
| 1987 | 4,401.2 | 1,797.4 | 3,477.6 | n/a | n/a | 1,420.2 | n/a | n/a |
| 1988 | 4,727.3 | 1,883.5 | 3,731.0 | n/a | n/a | 1,486.6 | n/a | n/a |

1/ From NIH Data Book (1966-88, and pre-publication). Items may not sum to totals due to rounding.

2/ From the U.S. Bureau of the Census (1988a,b).

## APPENDIX TABLE B8. Biomedical Science R and D Expenditures in Colleges and Universities, by Type of Institutional Control, 1960-87 ($ millions)

| Fiscal Year | Current Dollars 1/ | | | 1972 Dollars 2/ | | | Weighted Sum of Biomed. Sci. R and D Expend. in Last 3 Yrs. 3/ (Total, 1972 Dollars) |
|---|---|---|---|---|---|---|---|
| | Total | Public | Private | Total | Public | Private | |
| 1960 | 287.4 | n/a | n/a | 418.3 | n/a | n/a | 363.5 |
| 1961 | 339.4 | n/a | n/a | 489.8 | n/a | n/a | 422.6 |
| 1962 | 402.2 | n/a | n/a | 570.5 | n/a | n/a | 492.1 |
| 1963 | 480.9 | n/a | n/a | 671.6 | n/a | n/a | 575.6 |
| 1964 | 565.7 | n/a | n/a | 778.1 | n/a | n/a | 673.0 |
| 1965 | 638.0 | n/a | n/a | 858.7 | n/a | n/a | 771.6 |
| 1966 | 724.0 | n/a | n/a | 942.7 | n/a | n/a | 859.5 |
| 1967 | 795.0 | n/a | n/a | 1,006.3 | n/a | n/a | 937.6 |
| 1968 | 860.7 | n/a | n/a | 1,042.0 | n/a | n/a | 999.3 |
| 1969 | 917.3 | n/a | n/a | 1,058.0 | n/a | n/a | 1,037.1 |
| 1970 | 991.2 | n/a | n/a | 1,084.5 | n/a | n/a | 1,060.6 |
| 1971 | 1,054.7 | n/a | n/a | 1,098.6 | n/a | n/a | 1,081.4 |
| 1972 | 1,102.2 | 600.5 | 501.7 | 1,102.2 | 600.5 | 501.7 | 1,096.0 |
| 1973 | 1,252.9 | 691.2 | 561.8 | 1,184.2 | 653.3 | 531.0 | 1,121.8 |
| 1974 | 1,284.3 | 691.4 | 592.8 | 1,107.2 | 596.0 | 511.0 | 1,144.4 |
| 1975 | 1,517.0 | 825.5 | 691.5 | 1,192.6 | 649.0 | 543.6 | 1,147.8 |
| 1976 | 1,688.8 | 937.9 | 750.9 | 1,261.2 | 700.4 | 560.8 | 1,188.4 |
| 1977 | 1,798.2 | 1,002.3 | 795.9 | 1,269.0 | 707.3 | 561.7 | 1,246.0 |
| 1978 | 2,038.8 | 1,158.3 | 880.5 | 1,340.9 | 761.8 | 579.1 | 1,285.0 |
| 1979 | 2,230.0 | 1,238.5 | 991.5 | 1,347.8 | 748.5 | 599.2 | 1,324.6 |
| 1980 | 2,538.8 | 1,433.1 | 1,105.7 | 1,422.9 | 803.2 | 619.7 | 1,364.8 |
| 1981 | 2,906.9 | 1,669.5 | 1,237.4 | 1,489.6 | 855.5 | 634.1 | 1,420.8 |
| 1982 | 3,151.1 | 1,806.8 | 1,344.2 | 1,523.2 | 873.4 | 649.7 | 1,481.3 |
| 1983 | 3,386.5 | 1,968.0 | 1,418.6 | 1,570.5 | 912.7 | 657.9 | 1,526.6 |
| 1984 | 3,760.0 | 2,216.4 | 1,543.6 | 1,682.9 | 992.0 | 690.9 | 1,586.8 |
| 1985 | 4,223.0 | 2,490.6 | 1,732.4 | 1,829.7 | 1,079.1 | 750.6 | 1,691.5 |
| 1986 | 4,750.3 | 2,803.9 | 1,946.4 | 2,004.0 | 1,182.9 | 821.1 | 1,836.6 |
| 1987 | 5,309.2 | 3,119.4 | 2,189.7 | 2,168.3 | 1,274.0 | 894.3 | 2,001.5 |

1/ Figures for 1972-87 were obtained from the National Science Foundation (1975-88). The 1978 figures are NSF estimates. Items may not sum to totals due to rounding.

2/ 1972 dollars were obtained by using the Implicit GNP Price Deflator (U.S. Bureau of the Census--see Appendix Table A7). Items may not sum to totals due to rounding.

3/ Computed by the formula 1/4(Rt + 2Rt-1 + Rt-2), where R = total biomedical science R and D expenditures (1972 dollars).

## APPENDIX TABLE B9. Average Biomedical Science R and D Expenditures per School in Colleges and Universities, by Type of Institutional Control, 1972-87 1/ (1972 $, thousands)

| Fiscal Year | Average R and D Expenditures |  |  | Number of Schools Reporting 2/ |  |  |
|---|---|---|---|---|---|---|
|  | Total | Public | Private | Total | Public | Private |
| 1972 | 1,865 | 1,793 | 1,960 | 591 | 335 | 256 |
| 1973 | 2,004 | 1,950 | 2,074 | 591 | 335 | 256 |
| 1974 | 1,858 | 1,774 | 1,966 | 596 | 336 | 260 |
| 1975 | 2,225 | 2,009 | 2,552 | 536 | 323 | 213 |
| 1976 | 2,357 | 2,175 | 2,633 | 535 | 322 | 213 |
| 1977 | 2,368 | 2,197 | 2,625 | 536 | 322 | 214 |
| 1978 | 2,386 | 2,301 | 2,507 | 562 | 331 | 231 |
| 1979 | 2,385 | 2,255 | 2,572 | 565 | 332 | 233 |
| 1980 | 2,532 | 2,419 | 2,683 | 562 | 332 | 231 |
| 1981 | 2,665 | 2,577 | 2,745 | 559 | 332 | 231 |
| 1982 | 2,730 | 2,631 | 2,813 | 558 | 332 | 231 |
| 1983 | 2,795 | 2,757 | 2,848 | 562 | 331 | 231 |
| 1984 | 3,000 | n/a | n/a | 561 | n/a | n/a |
| 1985 | 3,262 | n/a | n/a | 561 | n/a | n/a |
| 1986 | 3,572 | n/a | n/a | 561 | n/a | n/a |
| 1987 | 3,858 | n/a | n/a | 562 | n/a | n/a |

1/See Appendix Table B9 for supporting data.

2/From the National Science Foundation (1975-88). For 1978, the number of doctorate-granting institutions was obtained from NSF; the number of master's-granting institutions was estimated by the committee. Beginning in FY 1984, data were collected from a sample of 400 institutions and inflated to produce universe estimates.

## APPENDIX TABLE B10. Indirect Costs of NIH-Sponsored Research Grants at Institutions of Higher Education, 1970-88 1/

| | All Institutions of Higher Education | | Public Schools | | Private Schools | |
|---|---|---|---|---|---|---|
| Fiscal Year | % of Direct Costs | % of Total Costs | % of Direct Costs | % of Total Costs | % of Direct Costs | % of Total Costs |
| 1970 | 25.7 | 20.5 | 26.6 | 21.0 | 24.9 | 19.9 |
| 1971 | 27.2 | 21.4 | 28.2 | 22.0 | 26.3 | 20.8 |
| 1972 | 28.7 | 22.3 | 28.9 | 22.4 | 28.5 | 22.2 |
| 1973 | 30.0 | 23.1 | 29.6 | 22.8 | 30.4 | 23.3 |
| 1974 | 31.8 | 24.1 | 30.4 | 23.3 | 33.2 | 24.9 |
| 1975 | 32.4 | 24.5 | 30.2 | 23.2 | 34.8 | 25.8 |
| 1976 | 34.6 | 25.7 | 31.7 | 24.1 | 37.6 | 27.4 |
| 1977 | 36.5 | 26.7 | 32.7 | 24.6 | 40.5 | 28.8 |
| 1978 | 37.4 | 27.2 | 33.0 | 24.8 | 42.1 | 29.6 |
| 1979 | 39.0 | 28.1 | 34.2 | 25.5 | 44.3 | 30.7 |
| 1980 | 40.8 | 29.0 | 34.7 | 25.8 | 47.8 | 32.3 |
| 1981 | 42.4 | 29.8 | 35.8 | 26.3 | 49.9 | 33.3 |
| 1982 | 43.3 | 30.2 | 36.3 | 26.8 | 51.4 | 34.0 |
| 1983 | 45.0 | 31.0 | 37.3 | 27.2 | 53.6 | 34.9 |
| 1984 | 45.8 | 31.4 | 38.5 | 27.8 | 54.0 | 35.1 |
| 1985 | 45.9 | 31.5 | 38.5 | 27.8 | 54.6 | 35.3 |
| 1986 | 46.2 | 31.6 | 39.3 | 28.2 | 54.3 | 35.2 |
| 1987 | 46.0 | 31.5 | 39.6 | 28.4 | 53.6 | 34.9 |
| 1988 | 45.7 | 31.3 | 40.2 | 28.7 | 52.0 | 34.2 |
| Average Annual Growth Rate 1970-88 | 3.2% | 2.4% | 2.3% | 1.8% | 4.2% | 3.1% |

1/ From NIH Data Book (1966-88 and pre-publication). Represents awards, not obligations. Unobligated balances from prior years' awards are carried forward as direct costs and therefore excluded. Also excludes RCPAs, BRS and BRD grants, conference grants, NCI education grants, and awards to minority student apprentice programs.

## APPENDIX TABLE B11. Ph.D.s Academically Employed in the Biomedical Sciences, by Employment Status and Type of Institution, 1973-87 1/

| Fiscal Year | Employment Status | Type of Institution<br>Total | 4-Year | 2-Year |
|---|---|---|---|---|
| 1973 | Total | 25,471 | 24,960 | 511 |
| | Full-Time | 24,724 | 24,241 | 483 |
| | Part-Time | 747 | 719 | 28 |
| 1975 | Total | 28,332 | 27,709 | 623 |
| | Full-Time | 27,487 | 26,919 | 568 |
| | Part-Time | 845 | 790 | 55 |
| 1977 | Total | 30,384 | 29,604 | 780 |
| | Full-Time | 29,473 | 28,768 | 705 |
| | Part-Time | 911 | 836 | 75 |
| 1979 | Total | 33,566 | 32,744 | 822 |
| | Full-Time | 32,550 | 31,802 | 749 |
| | Part-Time | 1,015 | 942 | 73 |
| 1981 | Total | 36,482 | 35,644 | 838 |
| | Full-Time | 35,462 | 34,701 | 761 |
| | Part-Time | 1,020 | 943 | 77 |
| 1983 | Total | 36,963 | 35,973 | 990 |
| | Full-Time | 35,781 | 34,884 | 897 |
| | Part-Time | 1,182 | 1,089 | 93 |
| 1985 | Total | 41,033 | 39,955 | 1,078 |
| | Full-Time | 39,665 | 38,679 | 985 |
| | Part-Time | 1,369 | 1,276 | 92 |
| 1987 | Total | 43,022 | 42,200 | 822 |
| | Full-Time | 41,438 | 40,708 | 730 |
| | Part-Time | 1,584 | 1,492 | 92 |
| Average Annual Growth Rate from 1973-87 | Total | 3.8% | 3.8% | 3.5% |
| | Full-Time | 3.8% | 3.8% | 3.0% |
| | Part-Time | 5.5% | 5.4% | 8.9% |

1/ Based on the most recent data available from the National Research Council's Survey of Doctorate Recipients (1973-88). Foreign nationals who received doctorates from U.S. institutions are included. Individuals on postdoctoral appointments are excluded.

## APPENDIX TABLE B12-1. Permanent Attrition Rates of U.S. Medical School Faculty, by Department and Degree Type, 1970-88 1/

| Fiscal Year | All Departments | | | | Clinical Departments | | | | Basic Science Departments | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | M.D.s | Ph.D.s | Other | Total | M.D.s | Ph.D.s | Other | Total | M.D.s | Ph.D.s | Other |
| 1970 | 5.0 | 5.1 | 3.6 | 7.6 | 5.7 | 5.4 | 6.1 | 7.1 | 4.0 | 5.8 | 2.8 | 5.4 |
| 1971 | 5.3 | 5.6 | 3.8 | 7.0 | 6.1 | 5.9 | 5.6 | 7.3 | 4.6 | 6.4 | 3.5 | 5.2 |
| 1972 | 6.4 | 6.2 | 5.1 | 9.8 | 6.8 | 6.5 | 6.7 | 8.8 | 6.0 | 7.1 | 5.4 | 5.9 |
| 1973 | 6.0 | 5.6 | 4.5 | 11.0 | 6.4 | 5.7 | 6.0 | 11.9 | 5.5 | 7.2 | 4.5 | 7.7 |
| 1974 | 5.5 | 5.5 | 4.0 | 9.2 | 5.9 | 5.6 | 5.8 | 8.4 | 4.9 | 6.7 | 3.9 | 6.2 |
| 1975 | 5.7 | 5.4 | 4.7 | 9.9 | 5.9 | 5.5 | 6.0 | 8.7 | 5.5 | 6.9 | 4.6 | 8.1 |
| 1976 | 6.4 | 6.3 | 5.0 | 10.9 | 6.8 | 6.5 | 6.5 | 10.6 | 5.9 | 7.1 | 5.0 | 9.9 |
| 1977 | 6.6 | 6.6 | 5.2 | 10.3 | 7.0 | 6.8 | 6.8 | 9.3 | 5.7 | 7.6 | 4.6 | 9.7 |
| 1978 | 5.9 | 5.7 | 4.5 | 11.5 | 6.2 | 5.8 | 6.2 | 9.6 | 5.2 | 7.0 | 4.3 | 7.6 |
| 1979 | 5.7 | 5.6 | 4.6 | 9.2 | 6.0 | 5.8 | 6.2 | 8.3 | 5.0 | 5.4 | 4.4 | 10.4 |
| 1980 | 5.6 | 5.6 | 4.8 | 8.6 | 5.9 | 5.7 | 5.7 | 8.1 | 5.4 | 6.2 | 4.9 | 9.0 |
| 1981 | 6.5 | 6.4 | 5.2 | 11.0 | 6.8 | 6.5 | 6.5 | 9.8 | 5.5 | 6.8 | 4.7 | 9.2 |
| 1982 | 6.3 | 6.1 | 5.5 | 10.5 | 6.5 | 6.2 | 6.9 | 9.5 | 5.9 | 6.5 | 5.1 | 14.7 |
| 1983 | 6.0 | 5.7 | 5.5 | 10.3 | 6.2 | 5.8 | 6.5 | 10.1 | 5.5 | 5.9 | 5.2 | 7.2 |
| 1984 | 5.8 | 5.6 | 5.6 | 8.1 | 6.0 | 5.7 | 6.7 | 8.2 | 5.0 | 5.9 | 4.5 | 7.0 |
| 1985 | 5.4 | 5.2 | 4.6 | 9.1 | 5.6 | 5.3 | 5.5 | 9.3 | 4.7 | 4.9 | 4.5 | 7.4 |
| 1986 | 4.8 | 5.0 | 4.0 | 6.5 | 5.2 | 5.1 | 5.0 | 6.5 | 4.0 | 4.1 | 3.8 | 6.1 |
| 1987 | 4.3 | 4.4 | 3.6 | 5.3 | 4.4 | 4.5 | 3.9 | 4.7 | 4.0 | 4.3 | 3.8 | 7.2 |
| 1988 | 0.3 | 0.3 | 0.2 | 0.8 | 0.3 | 0.3 | 0.2 | 0.6 | 0.2 | 0.2 | 0.2 | 0.2 |
| Avg 1970-87 | 5.7 | 5.6 | 4.7 | 9.2 | 6.1 | 5.8 | 6.0 | 8.7 | 5.1 | 6.2 | 4.4 | 8.0 |

1/ Based on special analyses of the AAMC Medical School Faculty Roster as of March, 1988. Numbers represent percent of full-time faculty leaving the department each year for retirement, death or other reasons (permanent attrition). Analyses performed at NIH/OSPL/DPE/PPRB.

## APPENDIX TABLE B12-2. One-Year-Out Attrition Rates of U.S. Medical School Faculty, by Department and Degree Type, 1970-88 1/

| Fiscal Year | All Departments | | | | Clinical Departments | | | | Basic Science Departments | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | M.D.s | PhD.s | Other | Total | M.D.s | PhD.s | Other | Total | M.D.s | PhD.s | Other |
| 1970 | 6.2 | 6.6 | 4.6 | 7.9 | 6.9 | 6.8 | 7.1 | 7.3 | 5.0 | 7.3 | 3.6 | 5.4 |
| 1971 | 6.3 | 6.8 | 4.5 | 7.5 | 7.0 | 7.1 | 6.2 | 7.6 | 5.3 | 7.4 | 4.1 | 5.6 |
| 1972 | 7.5 | 7.5 | 6.2 | 10.3 | 7.8 | 7.7 | 7.5 | 9.2 | 6.7 | 8.0 | 6.1 | 6.1 |
| 1973 | 7.0 | 7.0 | 5.1 | 11.5 | 7.5 | 7.0 | 6.8 | 12.1 | 6.0 | 8.0 | 4.8 | 7.8 |
| 1974 | 6.4 | 6.4 | 4.9 | 9.5 | 6.8 | 6.6 | 6.6 | 8.6 | 5.5 | 7.3 | 4.5 | 6.5 |
| | | | | | | | | | | | | |
| 1975 | 6.6 | 6.5 | 5.4 | 10.3 | 6.9 | 6.6 | 6.8 | 9.0 | 6.1 | 7.9 | 5.1 | 8.1 |
| 1976 | 7.3 | 7.3 | 5.8 | 11.3 | 7.7 | 7.4 | 7.3 | 10.9 | 6.5 | 8.1 | 5.5 | 9.9 |
| 1977 | 7.5 | 7.6 | 6.0 | 10.5 | 7.9 | 7.8 | 7.7 | 9.5 | 6.2 | 8.2 | 5.0 | 9.7 |
| 1978 | 6.7 | 6.6 | 5.2 | 11.7 | 7.0 | 6.7 | 6.8 | 9.8 | 5.7 | 7.6 | 4.7 | 7.9 |
| 1979 | 6.4 | 6.5 | 5.3 | 9.7 | 6.8 | 6.6 | 6.9 | 8.6 | 5.4 | 5.9 | 4.8 | 10.7 |
| | | | | | | | | | | | | |
| 1980 | 6.3 | 6.4 | 5.4 | 8.8 | 6.6 | 6.5 | 6.4 | 8.3 | 5.7 | 6.6 | 5.2 | 9.0 |
| 1981 | 7.1 | 7.1 | 5.7 | 11.2 | 7.5 | 7.3 | 7.1 | 9.9 | 5.8 | 7.1 | 5.1 | 9.3 |
| 1982 | 6.9 | 6.8 | 6.0 | 10.7 | 7.2 | 6.9 | 7.3 | 9.7 | 6.3 | 6.8 | 5.4 | 14.7 |
| 1983 | 6.6 | 6.4 | 5.9 | 10.4 | 6.9 | 6.5 | 7.0 | 10.2 | 5.7 | 6.2 | 5.4 | 7.2 |
| 1984 | 6.3 | 6.2 | 6.0 | 8.2 | 6.6 | 6.3 | 7.1 | 8.4 | 5.2 | 6.1 | 4.7 | 7.2 |
| | | | | | | | | | | | | |
| 1985 | 5.7 | 5.6 | 5.0 | 9.3 | 6.0 | 5.7 | 5.8 | 9.5 | 5.0 | 5.2 | 4.7 | 7.4 |
| 1986 | 5.1 | 5.2 | 4.2 | 6.6 | 5.4 | 5.4 | 5.0 | 6.7 | 4.1 | 4.3 | 3.9 | 6.1 |
| 1987 | 4.3 | 4.4 | 3.6 | 5.3 | 4.4 | 4.5 | 3.9 | 4.7 | 4.0 | 4.3 | 3.8 | 7.2 |
| 1988 | 0.3 | 0.3 | 0.2 | 0.8 | 0.3 | 0.3 | 0.2 | 0.6 | 0.2 | 0.2 | 0.2 | 0.2 |
| | | | | | | | | | | | | |
| Avg 1970-87 | 6.5 | 6.5 | 5.3 | 9.5 | 6.8 | 6.6 | 6.6 | 8.9 | 5.6 | 6.8 | 4.8 | 8.1 |

1/ Based on special analyses of the AAMC Medical School Faculty Roster as of March, 1988. Numbers represent percent of full-time faculty leaving the department for one year for any reason (one-year-out attrition).
Analyses performed at NIH/OSPL/DPE/PPRB.

## APPENDIX TABLE B13. Postdoctoral Research Training of New Faculty in U.S. Medical Schools, by Department and Degree Type, 1982-87 1/

| Fiscal Year | All Departments | | Clinical Departments | | Basic Science Departments | |
|---|---|---|---|---|---|---|
| | M.D.s | Ph.Ds | M.D.s | Ph.D.s | M.D.s | Ph.D.s |
| 1982 | 44.5 | 72.7 | 44.4 | 63.3 | 54.9 | 87.6 |
| 1983 | 43.6 | 73.4 | 41.6 | 61.2 | 48.5 | 89.9 |
| 1984 | 43.9 | 72.5 | 37.9 | 62.8 | 50.0 | 86.8 |
| 1985 | 41.5 | 72.2 | 39.9 | 62.8 | 49.5 | 87.3 |
| 1986 | 46.4 | 74.3 | 27.2 | 62.6 | 50.5 | 88.5 |
| 1987 | 35.3 | 53.7 | 19.2 | 60.1 | 46.7 | 85.1 |
| Avg 1982-87 | 42.5 | 69.8 | 35.0 | 62.1 | 50.0 | 87.5 |

1/ Based on special analyses of the AAMC Medical School Faculty Roster as of March, 1988. Numbers represent percent of new full-time faculty with any reported postdoctoral research training. Data collected under the current survey format are available only since 1982.

## APPENDIX TABLE B14. Graduate School Attrition Rates in the Biomedical Sciences, 1963-74

| Fiscal Year of Graduate School Entry | First-Year Graduate Enrollment in the Biomed. Sci. 1/ | Number of FY 1962-87 Biomedical Sci. Ph.D.s Entering Grad. School 2/ | Ph.D. Completion Rate (%) 3/ | Estimated Graduate School Attrition Rate (%) 3/ |
|---|---|---|---|---|
| Pre-1963 | | 16,314 | | |
| Post-1974 | | 23,904 | | |
| 1963 | 7,137 | 2,583 | 36.2 | 63.8 |
| 1964 | 8,542 | 3,096 | 36.2 | 63.8 |
| 1965 | 10,430 | 3,454 | 33.1 | 66.9 |
| 1966 | 12,034 | 3,814 | 31.7 | 68.3 |
| 1967 | 12,511 | 3,762 | 30.1 | 69.9 |
| 1968 | 13,301 | 3,591 | 27.0 | 73.0 |
| 1969 | 13,343 | 3,430 | 25.7 | 74.3 |
| 1970 | 14,835 | 3,551 | 23.9 | 76.1 |
| 1971 | 15,845 | 3,625 | 22.9 | 77.1 |
| 1972 | 16,722 | 3,633 | 21.7 | 78.3 |
| 1973 | 17,511 | 3,822 | 21.8 | 78.2 |
| 1974 | 17,538 | 3,737 | 21.3 | 78.7 |

1/From the U.S. Department of Education (1959-79).

2/From the National Research Council's Doctorate Records File (1958-88).

3/The Ph.D. completion rate represents the percentage of first-year graduate students in a given year who earned a Ph.D. between 1962 and 1987 (column 2/column 1). The attrition rate is obtained by subtracting the Ph.D. completion rate for a given year from 100.0%. The rates for 1960-64 are relatively constant (see 1985 Report), indicating that most individuals entering graduate school during that period had either received a Ph.D. or dropped out of graduate school by 1987. For later years, the Ph.D. completion rates decline with each year. The attrition rates for these years undoubtedly include students who are still enrolled in graduate school but who had not earned a Ph.D. by 1987, as well as those who had actually dropped out of graduate school. The median elapsed time from baccalaureate to bioscience doctorate degree in 1987 was 8.1 years; it is therefore probable that many of the graduate students entering in years after 1980 are still working toward a doctorate degree. Completion and attrition rates have not been calculated for the later years. The Ph.D. completion rates will most likely increase and the attrition rates decrease once 1988 Ph.D.s are added to the calculations, and should continue to do so with the inclusion of each additional year of Ph.D.s.

## APPENDIX TABLE B15. Percent of the Postdoctoral Population in the Biomedical Sciences Who Had Earned Their Doctorates More Than 2, 3, or 4 Years Earlier, 1973-87 1/

| | | Number of Years Since Ph.D. | | | | | |
|---|---|---|---|---|---|---|---|
| | | > 2 Years | | > 3 Years | | > 4 Years | |
| Fiscal Year | Total Postdocs | N | % | N | % | N | % |
| 1973 | 2,623 | 1,123 | 42.8 | 577 | 22.0 | 343 | 13.1 |
| 1975 | 4,316 | 2,239 | 51.9 | 1,334 | 30.9 | 843 | 19.5 |
| 1977 | 5,142 | 2,782 | 54.1 | 1,715 | 33.4 | 1,051 | 20.4 |
| 1979 | 6,106 | 3,530 | 57.8 | 2,345 | 38.4 | 1,532 | 25.1 |
| 1981 | 6,759 | 3,695 | 54.7 | 2,369 | 35.0 | 1,544 | 22.8 |
| 1983 | 6,579 | 3,503 | 53.2 | 2,309 | 35.1 | 1,432 | 21.8 |
| 1985 | 7,034 | 4,210 | 59.9 | 2,934 | 41.7 | 1,831 | 26.0 |
| 1987 | 6,872 | 3,847 | 56.0 | 2,445 | 35.6 | 1,578 | 23.0 |

1/Based on special analyses by National Research Council staff of the Survey of Doctorate Recipients (1973-1988).

## APPENDIX TABLE C1. Behavioral Science Enrollments in Colleges and Universities, by Type of Institutional Control, 1960-87 1/

| | Total Undergraduate and Graduate Enrollment | | | Estimated Undergraduate Enrollment 2/ | | | Graduate Enrollment 3/ | | |
|---|---|---|---|---|---|---|---|---|---|
| Fiscal Year | Total | Public | Private | Total | Public | Private | Total | Public | Private |
| 1960 | 172,976 | n/a | n/a | 160,228 | n/a | n/a | 12,748 | n/a | n/a |
| 1961 | 194,799 | n/a | n/a | 179,839 | n/a | n/a | 14,960 | n/a | n/a |
| 1962 | 225,475 | n/a | n/a | 210,099 | n/a | n/a | 15,376 | n/a | n/a |
| 1963 | 257,638 | n/a | n/a | 241,032 | n/a | n/a | 16,606 | n/a | n/a |
| 1964 | 304,375 | n/a | n/a | 285,593 | n/a | n/a | 18,782 | n/a | n/a |
| 1965 | 316,575 | n/a | n/a | 295,626 | n/a | n/a | 20,949 | n/a | n/a |
| 1966 | 382,904 | n/a | n/a | 358,840 | n/a | n/a | 24,064 | n/a | n/a |
| 1967 | 431,820 | n/a | n/a | 406,763 | n/a | n/a | 25,057 | n/a | n/a |
| 1968 | 495,958 | n/a | n/a | 466,075 | n/a | n/a | 29,883 | n/a | n/a |
| 1969 | 565,817 | n/a | n/a | 531,814 | n/a | n/a | 34,003 | n/a | n/a |
| 1970 | 637,063 | n/a | n/a | 600,555 | n/a | n/a | 36,508 | n/a | n/a |
| 1971 | 706,924 | n/a | n/a | 666,568 | 496,429 | 170,139 | 40,356 | n/a | n/a |
| 1972 | 750,453 | 563,722 | 186,731 | 705,746 | 533,011 | 172,735 | 44,707 | 30,711 | 13,996 |
| 1973 | 743,829 | 561,782 | 182.047 | 695,613 | 528,419 | 167,194 | 48.216 | 33,363 | 14,853 |
| 1974 | 724,277 | 550,163 | 174,114 | 672,565 | 514,787 | 157,778 | 51,712 | 35,376 | 16,336 |
| 1975 | 723,479 | 554,594 | 168,885 | 668,096 | 517,270 | 150,826 | 55,383 | 37,324 | 18,059 |
| 1976 | 730,900 | 564,051 | 166,849 | 671,844 | 524,078 | 147,766 | 59,056 | 39,973 | 19,083 |
| 1977 | 721,816 | n/a | n/a | 663,527 | n/a | n/a | 58,289 | 38,676 | 19,613 |
| 1978 | 712,713 | n/a | n/a | 648,933 | n/a | n/a | 63,780 | 43,153 | 20,627 |
| 1979 | 676,603 | n/a | n/a | 612,802 | n/a | n/a | 63,801 | 42,710 | 21,091 |
| 1980 | 668,593 | n/a | n/a | 604,773 | n/a | n/a | 63,820 | 42,264 | 21,556 |
| 1981 | 658,407 | n/a | n/a | 593,627 | n/a | n/a | 64,780 | 41,993 | 22,787 |
| 1982 | 654,146 | n/a | n/a | 589,815 | n/a | n/a | 64,331 | 41,701 | 22,630 |
| 1983 | 637,570 | n/a | n/a | 574,462 | n/a | n/a | 63,108 | 40,965 | 22,143 |
| 1984 | 647,413 | n/a | n/a | 583,700 | n/a | n/a | 63,713 | 41,406 | 22,307 |
| 1985 | n/a | n/a | n/a | n/a | n/a | n/a | 65,640 | 43,300 | 22,341 |
| 1986 | n/a | n/a | n/a | n/a | n/a | n/a | 65,269 | 42,813 | 22,459 |
| 1987 | n/a | n/a | n/a | n/a | n/a | n/a | 65,100 | 42,879 | 22,221 |

1/ Behavioral sciences include psychology, sociology, anthropology, and speech pathology/audiology. Figures are higher than those presented in the 1983 Report because speech pathology/audiology is now included in the taxonomy.

2/ Sum of estimated undergraduate enrollments in psychology, sociology, anthropology, and speech pathology/audiology. See Appendix Tables C4-6 and C8 for supporting data.

3/ Figures for 1960-77 were obtained from the U.S. Department of Education (1959-79). Figures for 1978-87 were obtained from the National Science Foundation (1973-88a) except for the 1979 figure, which was interpolated. Due to differences in taxonomy, NSF numbers for 1978-87 may be slightly higher than numbers that would have been obtained from the Department of Education had data been collected for those years. For the year 1977, NSF reported 62,699 graduate students enrolled in the behavioral sciences; in comparison, the Department of Education reported a somewhat lower figure of 58,289 (as shown in this table).

# APPENDIX TABLE C2. Graduate Enrollment in Clinical Psychology, Nonclinical Psychology, and Other Behavioral Sciences, and Ratio of Clinical Psychology Ph.D.s to Total Psychology Ph.D.s, by Type of Institutional Control, 1960-88

| Fiscal Year | Graduate Enrollment 1/ | | | | | | | | | Ratio of Clinical Psychology Ph.D.s to Total Psychology Ph.D.s 4/ |
|---|---|---|---|---|---|---|---|---|---|---|
| | Clinical Psychology 2/ | | | Nonclinical Psychology 2/ | | | Other Behavioral Sciences 3/ | | | |
| | Total | Public | Private | Total | Public | Private | Total | Public | Private | Total |
| 1960 | 3,788 | 1,962 | 1,826 | 5,169 | 2,677 | 2,492 | 3,791 | 1,977 | 1,814 | 0.4067 |
| 1961 | 4,403 | 2,301 | 2,102 | 6,274 | 3,279 | 2,995 | 4,283 | 2,401 | 1,882 | 0.4646 |
| 1962 | 4,978 | 2,638 | 2,340 | 5,773 | 3,060 | 2,713 | 4,625 | 2,595 | 2,030 | 0.4229 |
| 1963 | 4,733 | 2,655 | 2,078 | 6,611 | 3,708 | 2,903 | 5,262 | 3,093 | 2,169 | 0.4124 |
| 1964 | 4,867 | n/a | n/a | 7,760 | n/a | n/a | 6,155 | n/a | n/a | 0.4630 |
| 1965 | 5,610 | n/a | n/a | 8,123 | n/a | n/a | 7,216 | n/a | n/a | 0.4172 |
| 1966 | 6,511 | n/a | n/a | 9,040 | n/a | n/a | 8,513 | n/a | n/a | 0.3854 |
| 1967 | 5,949 | n/a | n/a | 9,736 | n/a | n/a | 9,372 | n/a | n/a | 0.4085 |
| 1968 | 7,139 | n/a | n/a | 11,925 | n/a | n/a | 10,819 | n/a | n/a | 0.4187 |
| 1969 | 8,525 | n/a | n/a | 13,118 | n/a | n/a | 12,360 | n/a | n/a | 0.3793 |
| 1970 | 9,160 | n/a | n/a | 13,566 | n/a | n/a | 13,782 | n/a | n/a | 0.3745 |
| 1971 | 10,877 | n/a | n/a | 14,465 | n/a | n/a | 15,014 | n/a | n/a | 0.3939 |
| 1972 | 10,909 | 7,147 | 3,743 | 15,803 | 10,649 | 5,173 | 17,995 | 12,915 | 5,080 | 0.4031 |
| 1973 | 12,125 | 8,505 | 3,656 | 17,032 | 11,164 | 5,832 | 19,059 | 13,694 | 5,365 | 0.4292 |
| 1974 | 13,858 | 9,006 | 4,845 | 17,041 | 11,210 | 5,838 | 20,813 | 15,160 | 5,653 | 0.4084 |
| 1975 | 14,840 | 9,625 | 5,224 | 17,954 | 11,285 | 6,660 | 22,589 | 16,414 | 6,175 | 0.4158 |
| 1976 | 16,925 | 10,481 | 6,437 | 18,393 | 11,588 | 6,812 | 23,738 | 17,904 | 5,834 | 0.4485 |
| 1977 | 17,264 | 10,295 | 6,979 | 18,099 | 11,098 | 6,991 | 22,926 | 17,283 | 5,643 | 0.4525 |
| 1978 | 19,713 | 12,070 | 7,606 | 18,915 | 12,002 | 6,950 | 23,754 | 18,217 | 5,537 | 0.4792 |
| 1979 | 20,351 | 11,764 | 8,509 | 18,856 | 12,266 | 6,668 | 23,277 | 17,886 | 5,391 | 0.4882 |
| 1980 | 21,178 | 12,545 | 8,613 | 18,608 | 11,443 | 7,185 | 22,798 | 17,553 | 5,245 | 0.5103 |
| 1981 | 21,651 | 11,958 | 9,708 | 18,985 | 11,823 | 7,147 | 22,938 | 17,490 | 5,448 | 0.5191 |
| 1982 | 21,744 | 12,484 | 9,295 | 18,947 | 11,381 | 7,531 | 22,530 | 17,202 | 5,328 | 0.5323 |
| 1983 | 21,921 | 12,407 | 9,579 | 18,177 | 10,985 | 7,127 | 21,877 | 16,935 | 4,942 | 0.5328 |
| 1984 | 22,834 | 12,753 | 10,169 | 18,254 | 11,392 | 6,774 | 21,425 | 16,651 | 4,774 | 0.5344 |
| 1985 | 24,585 | 14,650 | 9,947 | 19,616 | 12,181 | 7,423 | 20,350 | 15,908 | 4,442 | 0.5467 |
| 1986 | n/a | n/a | n/a | n/a | n/a | n/a | 20,362 | 15,589 | 4,774 | 0.5557 |
| 1987 | n/a | n/a | n/a | n/a | n/a | n/a | 20,380 | 15,780 | 4,600 | 0.5562 |
| 1988 | n/a | n/a | n/a | n/a | n/a | n/a | 20,395 | 15,774 | 4,621 | n/a |

1/ Figures for 1960-77 were obtained from the U.S. Department of Education (1959-79). Figures for 1978-88 were obtained from the National Science Foundation (1973-88a) except for the 1979 figure, which was interpolated. NSF numbers for 1978-88 may be slightly higher than numbers that would have been obtained from the Department of Education had data been collected for those years.

2/ Total graduate enrollment in clinical psychology was estimated by the formula $CGi=(CPi+2/TPi+2)Ei$, where $CGi$ = clinical psychology graduate enrollment in year i; $CPi+2$ = clinical psychology Ph.D. degrees awarded in year i+2; $TPi+2$ = total psychology Ph.D. degrees awarded in year i+2; $Ei$ = psychology graduate enrollment in year i. Public and private estimates were based on enrollment ratios. Nonclinical psychology graduate enrollment represents the difference between total psychology and clinical psychology graduate enrollments. See Appendix Tables C4 and C10 for supporting data.

3/ Includes sociology and anthropology for all years; includes speech pathology/audiology beginning in 1972. See Appendix Tables C5, C6, and C8 for supporting data.

4/ See Appendix Table C10 for number of Ph.D.s.

## APPENDIX TABLE C3. First-Year Graduate Enrollment in the Behavioral Sciences, 1960-88 1/

| | Total First-Year Graduate Enrollment 2/ | | | | | First-Year Full-time Graduate Enrollment in Doctorate-Granting Institutions 3/ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fiscal Year | All Behav. Sci. | Psych. | Sociol. | Anthro. | Spch.Path./ Audiology | All Behav. Sci. | Psych. | Sociol. | Anthro. | Sociol/ Anthro. | Spch.Path./ Audiology |
| 1960 | 6,188 | 4,366 | 1,486 | 336 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1961 | 7,732 | 5,470 | 1,805 | 457 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1962 | 8,038 | 5,655 | 1,861 | 522 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1963 | 8,739 | 6,169 | 2,020 | 550 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1964 | 9,288 | 5,928 | 2,625 | 735 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1965 | 11,832 | 7,673 | 3,137 | 1,022 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1966 | 13,659 | 8,765 | 3,645 | 1,249 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1967 | 13,659 | 8,459 | 3,793 | 1,407 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1968 | 15,966 | 10,190 | 4,290 | 1,486 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1969 | 16,831 | 10,645 | 4,584 | 1,602 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1970 | 19,501 | 12,200 | 5,456 | 1,845 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1971 | 22,709 | 14,262 | 6,033 | 2,414 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1972 | 24,607 | 14,754 | 5,484 | 2,366 | 2,003 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1973 | 26,269 | 15,678 | 5,642 | 2,525 | 2,424 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1974 | 27,636 | 16,219 | 5,404 | 2,515 | 3,498 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1975 | 29,376 | 17,270 | 5,257 | 2,554 | 4,295 | 12,028 | 5,872 | 1,930 | 1,368 | 338 | 2,520 |
| 1976 | 31,545 | 18,510 | 5,012 | 2,748 | 5,275 | 11,821 | 5,737 | 1,852 | 1,276 | 398 | 2,558 |
| 1977 | 29,778 | 17,565 | 4,461 | 2,525 | 5,227 | 11,606 | 5,983 | 1,706 | 1,335 | 259 | 2,323 |
| 1978 | n/a | n/a | n/a | n/a | n/a | 11,695 | 6,063 | 1,678 | 1,326 | 273 | 2,355 |
| 1979 | n/a | n/a | n/a | n/a | n/a | 10,390 | 5,569 | 1,371 | 1,141 | 218 | 2,091 |
| 1980 | n/a | n/a | n/a | n/a | n/a | 9,938 | 5,468 | 1,286 | 1,110 | 227 | 1,847 |
| 1981 | n/a | n/a | n/a | n/a | n/a | 10,227 | 5,697 | 1,314 | 966 | 203 | 2,047 |
| 1982 | n/a | n/a | n/a | n/a | n/a | 9,846 | 5,564 | 1,229 | 928 | 153 | 1,972 |
| 1983 | n/a | n/a | n/a | n/a | n/a | 9,650 | 5,474 | 1,130 | 896 | 200 | 1,950 |
| 1984 | n/a | n/a | n/a | n/a | n/a | 9,408 | 5,405 | 1,129 | 830 | 159 | 1,885 |
| 1985 | n/a | n/a | n/a | n/a | n/a | 9,477 | 5,441 | 1,094 | 869 | 139 | 1,934 |
| 1986 | n/a | n/a | n/a | n/a | n/a | 9,872 | 5,743 | 1,073 | 949 | 179 | 1,928 |
| 1987 | n/a | n/a | n/a | n/a | n/a | 9,555 | 5,560 | 1,070 | 911 | 182 | 1,832 |
| 1988 | n/a | n/a | n/a | n/a | n/a | 9,698 | 5,656 | 1,231 | 964 | 180 | 1,667 |

1/ Figures are higher than those presented in the 1983 Report because speech pathology/audiology is now included in the taxonomy.

2/ From the U.S. Department of Education (1959-79).

3/ From the National Science Foundation (1973-88a).

## APPENDIX TABLE C4. Psychology Enrollments in Colleges and Universities, B.A. Degrees Awarded in Psychology, and Ratio of Psychology B.A.s to Total B.A.s, by Type of Institutional Control, 1960-88

| | Enrollments | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total Undergraduate and Graduate Enrollment | | | Estimated Undergraduate Enrollment 1/ | | | Graduate Enrollment 2/ | | | B.A. Degrees Awarded 3/ | | | Ratio of Psych. B.A.s/ Total B.A.s 4/ |
| Fiscal Year | Total | Public | Private | Total | Public | Private | Total | Public | Private | Total | Public | Private | Total |
| 1960 | 92,894 | n/a | n/a | 83,937 | n/a | n/a | 8,957 | 4,639 | 4,318 | 8,111 | n/a | n/a | n/a |
| 1961 | 106,036 | n/a | n/a | 95,359 | n/a | n/a | 10,677 | 5,580 | 5,097 | 8,524 | n/a | n/a | 0.0233 |
| 1962 | 121,373 | n/a | n/a | 110,622 | n/a | n/a | 10,751 | 5,698 | 5,053 | 9,638 | n/a | n/a | 0.0252 |
| 1963 | 134.461 | n/a | n/a | 123,117 | n/a | n/a | 11,344 | 6,363 | 4,981 | 11,062 | n/a | n/a | 0.0270 |
| 1964 | 156,762 | n/a | n/a | 144,135 | n/a | n/a | 12,627 | n/a | n/a | 13,359 | n/a | n/a | 0.0290 |
| 1965 | 161,244 | n/a | n/a | 147,511 | n/a | n/a | 13,733 | n/a | n/a | 14,721 | n/a | n/a | 0.0299 |
| 1966 | 193,667 | n/a | n/a | 178,116 | n/a | n/a | 15,551 | n/a | n/a | 17,022 | n/a | n/a | 0.0325 |
| 1967 | 218,894 | n/a | n/a | 203,209 | 136,946 | 66,263 | 15,685 | n/a | n/a | 19,496 | n/a | n/a | 0.0347 |
| 1968 | 249,700 | n/a | n/a | 230,636 | 159,413 | 71,223 | 19,064 | n/a | n/a | 23,972 | n/a | n/a | 0.0376 |
| 1969 | 287,920 | n/a | n/a | 266,277 | 191,557 | 74,720 | 21,643 | n/a | n/a | 29,495 | 16,609 | 12,886 | 0.0402 |
| 1970 | 332,414 | n/a | n/a | 309,688 | 227,519 | 82,169 | 22,726 | n/a | n/a | 33,854 | 19,819 | 14,035 | 0.0424 |
| 1971 | 372,721 | n/a | n/a | 347,379 | 258,712 | 88,667 | 25,342 | n/a | n/a | 38,154 | 22,696 | 15,458 | 0.0451 |
| 1972 | 405,227 | 303,667 | 101,560 | 378,515 | 285,871 | 92,644 | 26,712 | 17,796 | 8,916 | 43,421 | 26,312 | 17,109 | 0.0486 |
| 1973 | 415,508 | 313,159 | 102,349 | 386,351 | 293,490 | 92,861 | 29,157 | 19,669 | 9,488 | 48,096 | 29,410 | 18,686 | 0.0517 |
| 1974 | 418,251 | 316,699 | 101,552 | 387,352 | 296,483 | 90,869 | 30,899 | 20,216 | 10,683 | 52,256 | 33,007 | 19,249 | 0.0548 |
| 1975 | 424,629 | 324,286 | 100,343 | 391,835 | 303,376 | 88,459 | 32,794 | 20,910 | 11,884 | 51,436 | 32,751 | 18,685 | 0.0552 |
| 1976 | 434,156 | 333,186 | 100,970 | 398,838 | 311,117 | 87,721 | 35,318 | 22,069 | 13,249 | 50,363 | 32,662 | 17,701 | 0.0539 |
| 1977 | 429,893 | 321,351 | 97,884 | 394,530 | n/a | n/a | 35,363 | 21,393 | 13,970 | 47,794 | 31,005 | 16,789 | 0.0515 |
| 1978 | 435,003 | 322,171 | 99,469 | 396,375 | n/a | n/a | 38,628 | 24,072 | 14,556 | 45,057 | 28,698 | 16,359 | 0.0484 |
| 1979 | 419,597 | 310,470 | 97,959 | 380,390 | n/a | n/a | 39,207 | 24,030 | 15,177 | 43,012 | 26,969 | 16,043 | 0.0462 |
| 1980 | 425,374 | 314,575 | 100,036 | 385,588 | n/a | n/a | 39,786 | 23,988 | 15,798 | 42,513 | 26,254 | 16,259 | 0.0452 |
| 1981 | 431,378 | 323,236 | 103,045 | 390,742 | n/a | n/a | 40,636 | 23,781 | 16,855 | 41,364 | 25,592 | 15,772 | 0.0437 |
| 1982 | 434,865 | n/a | n/a | 394,174 | n/a | n/a | 40,691 | 23,865 | 16,826 | 41,539 | 25,758 | 15,781 | 0.0431 |
| 1983 | 436,751 | n/a | n/a | 396,653 | n/a | n/a | 40,098 | 23,392 | 16,706 | 40,364 | n/a | n/a | 0.0416 |
| 1984 | 445,356 | n/a | n/a | 404,252 | n/a | n/a | 41,088 | 24,145 | 16,943 | 39,872 | n/a | n/a | 0.0409 |
| 1985 | n/a | n/a | n/a | n/a | n/a | n/a | 44,201 | 26,831 | 17,370 | 39,811 | n/a | n/a | 0.0406 |
| 1986 | n/a | n/a | n/a | n/a | n/a | n/a | 43,845 | 26,681 | 17,164 | 40,521 | n/a | n/a | 0.0410 |
| 1987 | n/a | n/a | n/a | n/a | n/a | n/a | 43,658 | 26,528 | 17,130 | 42,836 | n/a | n/a | 0.0432 |
| 1988 | n/a | n/a | n/a | n/a | n/a | n/a | 44,912 | 26,751 | 18,161 | n/a | n/a | n/a | n/a |

(See footnotes on the following page)

## APPENDIX TABLE C4 Continued

1/ Estimated by the formula $U_i=(A_{i+2}/B_{i+2})C_i$, where $U_i$=psychology undergraduate enrollment in year i; $A_{i+2}$=psychology baccalaureate degrees awarded in year i+2; $B_{i+2}$=total baccalaureate degrees awarded in year i+2; $C_i$=total undergraduate degree-credit enrollment in year i (excluding first professional) for 1960-1976. Due to changes in the survey form, total enrollment in 1977-1988 is defined as undergraduate enrollment less unclassified undergraduates. NCES defines unclassified undergraduates as non-degree seeking. Public and private estimates were based on enrollment ratios. See Appendix Table C9 for supporting data.

2/ Figures for 1960-77 were obtained from the U.S. Department of Education (1959-79). Figures for 1978-88 were obtained from the National Science Foundation (1973-88a) except for the 1979 figure, which was interpolated. Due to differences in taxonomy, NSF numbers for 1978-88 may be slightly higher than numbers that would have been obtained from the Department of Education had data been collected for those years. For the year 1977, NSF reported 37,427 graduate students enrolled in psychology; in comparison, the Department of Education reported a somewhat lower figure of 35,363 (as shown in this table).

3/ Figures for 1960-68 were obtained from the U.S. Department of Education (1948-81), those for 1969-86 from the U.S. Department of Education (1948-88).

4/ See Appendix Table C9 for total B.A.s.

## APPENDIX TABLE C5. Sociology Enrollments in Colleges and Universities, B.A. Degrees Awarded in Sociology, and Ratio of Sociology B.A.s to Total B.A.s, by Type of Institutional Control, 1960-88

| | Enrollments | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total Undergraduate and Graduate Enrollment | | | Estimated Undergraduate Enrollment 1/ | | | Graduate Enrollment 2/ | | | B.A. Degrees Awarded 3/ | | | Ratio of Sociol. B.A.s to Total B.A.s 4/ |
| Fiscal Year | Total | Public | Private | Total | Public | Private | Total | Public | Private | Total | Public | Private | Total |
| 1960 | 74,195 | n/a | n/a | 71,266 | n/a | n/a | 2,929 | 1,540 | 1,389 | 7,182 | n/a | n/a | n/a |
| 1961 | 81,326 | n/a | n/a | 78,049 | n/a | n/a | 3,277 | 1,863 | 1,414 | 7,519 | n/a | n/a | 0.0206 |
| 1962 | 94,982 | n/a | n/a | 91,494 | n/a | n/a | 3,488 | 1,975 | 1,513 | 8,183 | n/a | n/a | 0.0214 |
| 1963 | 111,778 | n/a | n/a | 107,854 | n/a | n/a | 3,924 | 2,328 | 1,596 | 9,054 | n/a | n/a | 0.0221 |
| 1964 | 133,335 | n/a | n/a | 128,732 | n/a | n/a | 4,603 | n/a | n/a | 11,049 | n/a | n/a | 0.0240 |
| 1965 | 139,652 | n/a | n/a | 134,307 | n/a | n/a | 5,345 | n/a | n/a | 12,896 | n/a | n/a | 0.0262 |
| 1966 | 170,114 | n/a | n/a | 163,924 | n/a | n/a | 6,190 | n/a | n/a | 15,203 | n/a | n/a | 0.0290 |
| 1967 | 189,642 | n/a | n/a | 182,954 | 123,296 | 59,658 | 6,688 | n/a | n/a | 17,751 | n/a | n/a | 0.0316 |
| 1968 | 217,927 | n/a | n/a | 210,157 | 145,258 | 64,899 | 7,770 | n/a | n/a | 22,062 | n/a | n/a | 0.0346 |
| 1969 | 243,609 | n/a | n/a | 234,927 | 169,004 | 65,923 | 8,682 | n/a | n/a | 26,555 | 14,604 | 11,951 | 0.0362 |
| 1970 | 263,958 | n/a | n/a | 254,093 | 186,675 | 67,418 | 9,865 | n/a | n/a | 30,848 | 17,820 | 13,028 | 0.0387 |
| 1971 | 270,294 | n/a | n/a | 259,971 | 193,614 | 66,357 | 10,323 | n/a | n/a | 33,662 | 19,992 | 13,670 | 0.0398 |
| 1972 | 270,184 | 203,360 | 66,824 | 260,012 | 196,372 | 63,640 | 10,172 | 6,988 | 3,184 | 35,626 | 21,783 | 13,843 | 0.0398 |
| 1973 | 249,429 | 188,734 | 60,695 | 238,987 | 181,545 | 57,442 | 10,442 | 7,189 | 3,253 | 35,994 | 22,780 | 13,214 | 0.0387 |
| 1974 | 225,615 | 172,021 | 53,594 | 215,123 | 164,657 | 50,466 | 10,492 | 7,364 | 3,128 | 35,896 | 23,387 | 12,509 | 0.0376 |
| 1975 | 215,344 | 166,070 | 49,274 | 204,870 | 158,619 | 46,251 | 10,474 | 7,451 | 3,023 | 31,817 | 20,790 | 11,027 | 0.0342 |
| 1976 | 213,928 | 166,275 | 47,653 | 203,512 | 158,751 | 44,761 | 10,416 | 7,524 | 2,892 | 27,970 | 18,506 | 9,464 | 0.0299 |
| 1977 | 198,399 | 150,147 | 42,886 | 188,725 | n/a | n/a | 9,674 | 6,870 | 2,804 | 24,989 | 16,569 | 8,420 | 0.0269 |
| 1978 | 187,759 | 140,598 | 40,919 | 178,895 | n/a | n/a | 8,864 | 6,222 | 2,642 | 22,991 | 15,324 | 7,667 | 0.0247 |
| 1979 | 170,417 | 127,751 | 37,701 | 161,905 | n/a | n/a | 8,512 | 5,998 | 2,514 | 20,545 | 13,531 | 7,014 | 0.0221 |
| 1980 | 159,352 | 119,968 | 35,489 | 151,193 | n/a | n/a | 8,159 | 5,774 | 2,385 | 19,164 | 12,494 | 6,670 | 0.0204 |
| 1981 | 144,197 | 112,673 | 33,253 | 136,196 | n/a | n/a | 8,001 | 5,574 | 2,427 | 17,582 | 11,371 | 6,211 | 0.0186 |
| 1982 | 137,922 | n/a | n/a | 130,106 | n/a | n/a | 7,816 | 5,461 | 2,355 | 16,324 | 10,574 | 5,750 | 0.0169 |
| 1983 | 126,437 | n/a | n/a | 119,191 | n/a | n/a | 7,246 | 5,168 | 2,078 | 14,105 | n/a | n/a | 0.0145 |
| 1984 | 129,211 | n/a | n/a | 122,262 | n/a | n/a | 6,949 | 5,027 | 1,922 | 13,145 | n/a | n/a | 0.0135 |
| 1985 | n/a | n/a | n/a | n/a | n/a | n/a | 6,862 | 5,090 | 1,772 | 11,968 | n/a | n/a | 0.0122 |
| 1986 | n/a | n/a | n/a | n/a | n/a | n/a | 6,593 | 4,835 | 1,758 | 12,271 | n/a | n/a | 0.0124 |
| 1987 | n/a | n/a | n/a | n/a | n/a | n/a | 6,537 | 4,884 | 1,653 | 12,239 | n/a | n/a | 0.0124 |
| 1988 | n/a | n/a | n/a | n/a | n/a | n/a | 7,020 | 5,271 | 1,749 | n/a | n/a | n/a | n/a |

(See footnotes on the following page)

## APPENDIX TABLE C5 Continued

1/ Estimated by the formula Ui=(Ai+2/Bi+2)Ci, where Ui = sociology undergraduate enrollment in year i; Ai+2 = sociology baccalaureate degrees awarded in year i+2; Bi+2 = total baccalaureate degrees awarded in year i+2; Ci = total undergraduate degree-credit enrollment in year i (excluding first professional) in 1960-1976. Due to changes in the survey form, total enrollment in 1977-1988 is defined as undergraduate enrollment less unclassified undergraduates. NCES defines unclassified undergraduates as non-degree seeking. Public and private estimates were based on enrollment ratios. See Appendix Table C9 for supporting data.

2/ Figures for 1960-77 were obtained from the U.S. Department of Education (1959-79). Figures for 1978-88 were obtained from the National Science Foundation (1973-88a) except for the 1979 figure, which was interpolated. Due to differences in taxonomy, NSF numbers for 1978-88 may be slightly higher than numbers that would have been obtained from the Department of Education had data been collected for those years. For the year 1977, NSF reported 9,686 graduate students enrolled in sociology (with an additional 1,239 enrolled in sociology/anthropology); in comparison, the Department of Education reported a somewhat lower figure of 9,674 (as shown in this table). Graduate enrollments in the interdisciplinary field of sociology/anthropology are not included in this table, but are presented in Appendix Table C7.

3/ Figures for 1960-68 were obtained from the U.S. Department of Education (1948-81), those for 1969-86 from the U.S. Department of Education (1948-88).

4/ See Appendix Table C9 for total B.A.s.

## APPENDIX TABLE C6. Anthropology Enrollments in Colleges and Universities, B.A. Degrees Awarded in Anthropology, and Ratio of Anthropology B.A.s to Total B.A.s, by Type of Institutional Control, 1960-88

| | Enrollments | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total Graduate and Undergraduate Enrollment | | | Estimated Undergraduate Enrollment 1/ | | | Graduate Enrollment 2/ | | | B.A. Degrees Awarded 3/ | | | Ratio of Anthro B.A.s to Total B.A.s 4/ |
| Fiscal Year | Total | Public | Private | Total | Public | Private | Total | Public | Private | Total | Public | Private | Total |
| 1960 | 5,887 | n/a | n/a | 5,025 | n/a | n/a | 862 | 437 | 425 | 413 | n/a | n/a | n/a |
| 1961 | 7,437 | n/a | n/a | 6,431 | n/a | n/a | 1,006 | 538 | 468 | 484 | n/a | n/a | 0.0013 |
| 1962 | 9,120 | n/a | n/a | 7,983 | n/a | n/a | 1,137 | 620 | 517 | 577 | n/a | n/a | 0.0015 |
| 1963 | 11,399 | n/a | n/a | 10,061 | n/a | n/a | 1,338 | 765 | 573 | 746 | n/a | n/a | 0.0018 |
| 1964 | 14,278 | n/a | n/a | 12,726 | n/a | n/a | 1,552 | n/a | n/a | 964 | n/a | n/a | 0.0021 |
| 1965 | 15,679 | n/a | n/a | 13,808 | n/a | n/a | 1,871 | n/a | n/a | 1,203 | n/a | n/a | 0.0024 |
| 1966 | 19,123 | n/a | n/a | 16,800 | n/a | n/a | 2,323 | n/a | n/a | 1,503 | n/a | n/a | 0.0029 |
| 1967 | 23,284 | n/a | n/a | 20,600 | 13,883 | 6,717 | 2,684 | n/a | n/a | 1,825 | n/a | n/a | 0.0032 |
| 1968 | 28,331 | n/a | n/a | 25,282 | 17,475 | 7,807 | 3,049 | n/a | n/a | 2,261 | n/a | n/a | 0.0036 |
| 1969 | 34,288 | n/a | n/a | 30,610 | 22,021 | 8,589 | 3,678 | n/a | n/a | 2,990 | 2,321 | 669 | 0.0041 |
| 1970 | 40,691 | n/a | n/a | 36,774 | 27,017 | 9,757 | 3,917 | n/a | n/a | 3,711 | 2,894 | 817 | 0.0046 |
| 1971 | 45,318 | n/a | n/a | 40,627 | 30,257 | 10,370 | 4,691 | n/a | n/a | 4,386 | 3,417 | 969 | 0.0052 |
| 1972 | 48,476 | 36,443 | 12,033 | 43,475 | 32,834 | 10,641 | 5,001 | 3,609 | 1,392 | 5,156 | 4,034 | 1,122 | 0.0058 |
| 1973 | 47,477 | 36,001 | 11,476 | 42,243 | 32,090 | 10,153 | 5,234 | 3,911 | 1,323 | 5,625 | 4,397 | 1,228 | 0.0060 |
| 1974 | 45,472 | 34,589 | 10,883 | 39,902 | 30,541 | 9,361 | 5,570 | 4,048 | 1,522 | 6,002 | 4,756 | 1,246 | 0.0063 |
| 1975 | 45,481 | 34,940 | 10,541 | 39,713 | 30,748 | 8,965 | 5,768 | 4,192 | 1,576 | 5,624 | 4,430 | 1,194 | 0.0060 |
| 1976 | 44,124 | 34,183 | 9,941 | 38,062 | 29,691 | 8,371 | 6,062 | 4,492 | 1,570 | 5,188 | 4,081 | 1,107 | 0.0056 |
| 1977 | 50,350 | 32,328 | 9,297 | 44,406 | n/a | n/a | 5,944 | 4,447 | 1,497 | 4,844 | 3,816 | 1,028 | 0.0052 |
| 1978 | 47,067 | 30,275 | 8,940 | 40,339 | n/a | n/a | 6,728 | 4,990 | 1,738 | 4,300 | 3,353 | 947 | 0.0046 |
| 1979 | 43,966 | 28,022 | 8,344 | 37,430 | n/a | n/a | 6,536 | 4,880 | 1,656 | 3,998 | 3,018 | 980 | 0.0043 |
| 1980 | 40,339 | 26,294 | 7,814 | 33,996 | n/a | n/a | 6,343 | 4,769 | 1,574 | 3,606 | 2,773 | 833 | 0.0038 |
| 1981 | 39,197 | 25,084 | 7,553 | 32,875 | n/a | n/a | 6,322 | 4,650 | 1,672 | 3,342 | 2,465 | 877 | 0.0035 |
| 1982 | 36,958 | n/a | n/a | 30,840 | n/a | n/a | 6,118 | 4,442 | 1,676 | 3,077 | 2,281 | 796 | 0.0032 |
| 1983 | 34,280 | n/a | n/a | 28,332 | n/a | n/a | 5,948 | 4,293 | 1,655 | 2,806 | n/a | n/a | 0.0029 |
| 1984 | 33,251 | n/a | n/a | 27,607 | n/a | n/a | 5,644 | 4,061 | 1,583 | 2,693 | n/a | n/a | 0.0028 |
| 1985 | n/a | n/a | n/a | n/a | n/a | n/a | 5,605 | 4,087 | 1,518 | 2,625 | n/a | n/a | 0.0027 |
| 1986 | n/a | n/a | n/a | n/a | n/a | n/a | 5,616 | 4,076 | 1,540 | 2,594 | n/a | n/a | 0.0026 |
| 1987 | n/a | n/a | n/a | n/a | n/a | n/a | 5,836 | 4,182 | 1,654 | 2,730 | n/a | n/a | 0.0028 |
| 1988 | n/a | n/a | n/a | n/a | n/a | n/a | 5,887 | 4,245 | 1,642 | n/a | n/a | n/a | n/a |

(See footnotes on the following page)

## APPENDIX TABLE C6 Continued

1/ Estimated by the formula Ui=(Ai+2/Bi+2)Ci, where Ui = anthropology undergraduate enrollment in year i; Ai+2 = anthropology baccalaureate degrees awarded in year i+2; Bi+2 = total baccalaureate degrees awarded in year i+2; Ci = total undergraduate degree-credit enrollment in year i (excluding first professional) in 1960-1976. Due to changes in the survey form, total enrollment in 1977-1988 is defined as undergraduate enrollment less unclassified undergraduates. NCES defines unclassified undergraduates as non-degree seeking. Public and private estimates were based on enrollment ratios. See Appendix Table C9 for supporting data.

2/ Figures for 1960-77 were obtained from the U.S. Department of Education (1959-79). Figures for 1978-88 were obtained from the National Science Foundation (1973-88a) except for the 1979 figure, which was interpolated. Due to differences in taxonomy, NSF numbers for 1978-88 may be slightly higher than numbers that would have been obtained from the Department of Education had data been collected for those years. For the year 1977, NSF reported 6,622 graduate students enrolled in anthropology (with an additional 1,239 enrolled in sociology/anthropology); in comparison, the Department of Education reported a somewhat lower figure of 5,944 (as shown in this table). Graduate enrollments in the interdisciplinary field of sociology/anthropology are not included in this table, but are presented in Appendix Table C7.

3/ Figures for 1960-68 were obtained from the U.S. Department of Education (1948-81), those for 1969-86 from the U.S. Department of Education (1948-88).

4/ See Appendix Table C9 for total B.A.s.

## APPENDIX TABLE C7. Graduate Enrollment in Sociology/Anthropology (Interdisciplinary), by Type of Institutional Control, 1978-88 1/

| Fiscal Year | Total | Public | Private |
|---|---|---|---|
| 1978 | 1,398 | 864 | 534 |
| 1979 | 1,317 | 794 | 523 |
| 1980 | 1,236 | 723 | 513 |
| 1981 | 1,206 | 722 | 484 |
| 1982 | 1,110 | 634 | 476 |
| 1983 | 1,133 | 638 | 495 |
| 1984 | 1,200 | 610 | 590 |
| 1985 | 1,090 | 561 | 529 |
| 1986 | 1,064 | 543 | 521 |
| 1987 | 1,062 | 571 | 491 |
| 1988 | 1,000 | 572 | 428 |

1/ From the National Science Foundation (1973-88a). The figures for 1979 were interpolated. The NSF taxonomy includes the interdisciplinary field of sociology/anthropology as well as the separate fields of sociology and anthropology. Sociology/anthropology is included in the total graduate enrollment data presented in Appendix Table C1. It is not included in Appendix Tables C5 and C6 which present graduate enrollments in sociology and anthropology.

## APPENDIX TABLE C8. Speech Pathology/Audiology Enrollments in Colleges and Universities, B.A. Degrees Awarded in Speech Pathology/Audiology, and Ratio of Speech Pathology/Audiology B.A.s to Total B.A.s, by Type of Institutional Control, 1971-88

| | Enrollments | | | | | | | | | | | | Ratio of Speech Path./ Audiol. B.A.s to Total B.A.s 4/ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total Undergraduate and Graduate Enrollment | | | Estimated Undergraduate Enrollment 1/ | | | Graduate Enrollment 2/ | | | B.A. Degrees awarded 3/ | | | |
| Fiscal Year | Total | Public | Private | Total | Public | Private | Total | Public | Private | Total | Public | Private | Total |
| 1971 | n/a | n/a | n/a | 18,591 | 13,846 | 4,745 | n/a | n/a | n/a | 1,427 | 1,070 | 357 | 0.0017 |
| 1972 | 26,566 | 20,251 | 6,315 | 23,744 | 17,933 | 5,811 | 2,822 | 2,318 | 504 | 1,863 | 1,489 | 374 | 0.0021 |
| 1973 | 31,415 | 23,888 | 7,527 | 28,032 | 21,294 | 6,738 | 3,383 | 2,594 | 789 | 2,574 | 2,117 | 457 | 0.0028 |
| 1974 | 34,939 | 26,854 | 8,085 | 30,188 | 23,106 | 7,082 | 4,751 | 3,748 | 1,003 | 3,278 | 2,713 | 565 | 0.0034 |
| 1975 | 38,025 | 29,298 | 8,727 | 31,678 | 24,527 | 7,151 | 6,347 | 4,771 | 1,576 | 3,732 | 3,172 | 560 | 0.0040 |
| 1976 | 38,692 | 30,407 | 8,285 | 31,432 | 24,519 | 6,913 | 7,260 | 5,888 | 1,372 | 3,925 | 3,360 | 565 | 0.0042 |
| 1977 | 43,174 | 30,751 | 8,276 | 35,866 | n/a | n/a | 7,308 | 5,966 | 1,342 | 3,864 | 3,295 | 569 | 0.0042 |
| 1978 | 41,486 | 32,068 | 8,412 | 33,324 | n/a | n/a | 8,162 | 7,005 | 1,157 | 3,551 | 2,842 | 709 | 0.0038 |
| 1979 | 41,306 | 30,851 | 8,230 | 33,077 | n/a | n/a | 8,229 | 7,008 | 1,221 | 3,554 | 2,967 | 587 | 0.0038 |
| 1980 | 42,292 | 31,104 | 8,389 | 33,996 | n/a | n/a | 8,296 | 7,010 | 1,286 | 3,576 | 2,954 | 622 | 0.0038 |
| 1981 | 42,429 | 32,627 | 8,774 | 33,814 | n/a | n/a | 8,615 | 7,266 | 1,349 | 3,445 | 2,906 | 539 | 0.0036 |
| 1982 | 43,291 | n/a | n/a | 34,695 | n/a | n/a | 8,596 | 7,299 | 1,297 | 3,446 | 2,963 | 483 | 0.0036 |
| 1983 | 38,969 | n/a | n/a | 30,286 | n/a | n/a | 8,683 | 7,474 | 1,209 | 3,041 | n/a | n/a | 0.0031 |
| 1984 | 38,411 | n/a | n/a | 29,579 | n/a | n/a | 8,832 | 7,563 | 1,269 | 2,901 | n/a | n/a | 0.0030 |
| 1985 | n/a | n/a | n/a | n/a | n/a | n/a | 7,883 | 6,731 | 1,152 | 2,526 | n/a | n/a | 0.0026 |
| | | | | | | | | | | | n/a | n/a | |
| 1986 | n/a | n/a | n/a | n/a | n/a | n/a | 8,153 | 6,678 | 1,476 | 2,464 | n/a | n/a | 0.0025 |
| 1987 | n/a | n/a | n/a | n/a | n/a | n/a | 8,007 | 6,714 | 1,293 | 2,563 | n/a | n/a | 0.0026 |
| 1988 | n/a | n/a | n/a | n/a | n/a | n/a | 7,488 | 6,258 | 1,230 | n/a | n/a | n/a | n/a |

1/ Estimated by the formula Ui=(Ai+2/Bi+2)Ci, where Ui = speech pathology/audiology undergraduate enrollment in year i; Ai+2 = speech pathology/audiology baccalaureate degrees awarded in year i+2; Bi+2 = total baccalaureate degrees awarded in year i+2; Ci = total undergraduate degree-credit enrollment in year i (excluding first professional). Public and private estimates were based on enrollment ratios. See Appendix Table C9 for supporting data.

2/ Figures for 1971-77 were obtained from the U.S. Department of Education (1959-79). Figures for 1978-88 were obtained from the National Science Foundation (1973-88a) except for the 1979 figure, which was interpolated. Due to differences in taxonomy, NSF numbers for 1978-88 may be slightly higher than numbers that would have been obtained from the Department of Education had data been collected for those years. For the year 1977, NSF reported 7,725 graduate students enrolled in speech pathology/audiology; in comparison, the Department of Education reported a somewhat lower figure of 7,308 (as shown in this table).

3/ Figures for 1971-86 were obtained from the U.S. Department of Education (1948-88).

4/ See Appendix Table C9 for total B.A.s.

## APPENDIX TABLE C9. Total Undergraduate Degree-Credit Enrollment, Total B.A. Degrees, and B.A. Degrees Awarded in the Behavioral Sciences, by Type of Institutional Control, 1960-87

| | Total Undergraduate Degree-Credit Enrollment (thousands) 1/ | | | | | | Total B.A. Degrees Awarded (excluding first professional) 4/ | | | B.A. Degrees Awarded in Behavioral Sciences 4/ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Including First Professional 2/ | | | Excluding First Professional 3/ | | | | | | | | |
| Fiscal Year | Total | Public | Private | Total | Public | Private | Total | Public | Private | Total | Public | Private |
| 1960 | 3,402 | n/a | n/a | 3,334 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1961 | 3,610 | n/a | n/a | 3,538 | n/a | n/a | 365,337 | n/a | n/a | 16,527 | n/a | n/a |
| 1962 | 3,891 | n/a | n/a | 3,813 | n/a | n/a | 382,822 | n/a | n/a | 18,398 | n/a | n/a |
| 1963 | 4,207 | n/a | n/a | 4,123 | n/a | n/a | 410,421 | n/a | n/a | 20,862 | n/a | n/a |
| 1964 | 4,529 | n/a | n/a | 4,438 | n/a | n/a | 460,467 | n/a | n/a | 25,372 | n/a | n/a |
| 1965 | 4,343 | 2,802 | 1,541 | 4,255 | n/a | n/a | 492,984 | n/a | n/a | 28,820 | n/a | n/a |
| 1966 | 4,829 | 3,184 | 1,645 | 4,732 | n/a | n/a | 524,117 | n/a | n/a | 33,728 | n/a | n/a |
| 1967 | 5,160 | 3,451 | 1,709 | 5,057 | 3,408 | 1,649 | 562,369 | n/a | n/a | 39,072 | n/a | n/a |
| 1968 | 5,557 | 3,810 | 1,747 | 5,437 | 3,758 | 1,679 | 636,863 | n/a | n/a | 48,295 | n/a | n/a |
| 1969 | 6,043 | 4,308 | 1,735 | 5,905 | 4,248 | 1,657 | 734,002 | 466,133 | 267,869 | 59,040 | 33,534 | 25,506 |
| 1970 | 6,529 | 4,749 | 1,780 | 6,377 | 4,685 | 1,692 | 798,070 | 523,442 | 274,628 | 68,413 | 40,533 | 27,880 |
| 1971 | 6,889 | 5,076 | 1,813 | 6,719 | 5,004 | 1,715 | 846,110 | 562,345 | 283,765 | 77,629 | 47,175 | 30,454 |
| 1972 | 7,104 | 5,302 | 1,802 | 6,913 | 5,221 | 1,692 | 894,110 | 604,471 | 289,639 | 86,066 | 53,618 | 32,448 |
| 1973 | 7,200 | 5,401 | 1,799 | 6,998 | 5,316 | 1,682 | 930,272 | 636,378 | 293,894 | 92,289 | 58,704 | 33,585 |
| 1974 | 7,396 | 5,589 | 1,807 | 7,187 | 5,501 | 1,686 | 954,376 | 657,455 | 296,921 | 97,432 | 63,863 | 33,569 |
| 1975 | 7,833 | 5,986 | 1,847 | 7,610 | 5,892 | 1,718 | 931,663 | 640,524 | 291,139 | 92,609 | 61,143 | 31,466 |
| 1976 | 8,468 | 6,520 | 1,948 | 8,234 | 6,423 | 1,811 | 934,443 | 640,799 | 293,644 | 87,446 | 58,609 | 28,837 |
| 1977 | 8,786 | n/a | n/a | 8,540 | n/a | n/a | 928,228 | 635,909 | 292,319 | 81,491 | 54,685 | 26,806 |
| 1978 | 9,022 | n/a | n/a | 8,769 | n/a | n/a | 930,201 | 633,183 | 297,018 | 75,899 | 50,217 | 25,682 |
| 1979 | 8,963 | n/a | n/a | 8,705 | n/a | n/a | 931,340 | 627,084 | 304,256 | 71,109 | 46,485 | 24,624 |
| 1980 | 9,211 | n/a | n/a | 8,946 | n/a | n/a | 940,251 | 629,338 | 310,913 | 68,859 | 44,475 | 24,384 |
| 1981 | 9,673 | n/a | n/a | 9,393 | n/a | n/a | 946,877 | 632,168 | 314,709 | 65,733 | 42,334 | 23,399 |
| 1982 | 9,914 | n/a | n/a | 9,638 | n/a | n/a | 964,043 | 641,751 | 322,292 | 64,386 | 41,576 | 22,810 |
| 1983 | 10,050 | n/a | n/a | 9,770 | n/a | n/a | 969,510 | n/a | n/a | 60,316 | n/a | n/a |
| 1984 | 10,140 | n/a | n/a | 9,860 | n/a | n/a | 974,309 | n/a | n/a | 58,611 | n/a | n/a |
| 1985 | 9,928 | n/a | n/a | 9,647 | n/a | n/a | 979,477 | n/a | n/a | 56,930 | n/a | n/a |
| 1986 | 9,838 | n/a | n/a | 9,561 | n/a | n/a | 987,823 | n/a | n/a | 57,850 | n/a | n/a |
| 1987 | 10,168 | n/a | n/a | 9,894 | n/a | n/a | 991,264 | 659,260 | 332,004 | 60,368 | n/a | n/a |

(See footnotes on the following page)

## APPENDIX TABLE C9 Continued

1/ The Department of Education last collected data on "degree-credit" enrollment in FY 1976; beginning in FY 1977, the survey collected data on "unclassified undergraduates", defined as non-degree-seeking students. Beginning in FY 1977, undergraduate degree-credit enrollment is defined as total undergraduate enrollment excluding unclassified undergraduates.

2/ Figures for 1960-64 were obtained from the U.S. Department of Education (1961-84), those for 1965-75 from the U.S. Department of Education, (1973-82), and the one for 1976 from the U.S. Department of Education (1974-87). Figures for 1977-87 are from the U.S. Department of Education (1961-88).

3/ Figures for 1960-66 were estimated at 98% of total undergraduate degree-credit enrollment (including first professional). Those for 1967-76 were obtained by subtracting first professional enrollment from total degree-credit undergraduate enrollment (including first professional). First professional enrollment data for 1967-76 were obtained from the U.S. Department of Education (1959-79), data for 1977-87 from the U.S. Department of Education (1961-88).

4/ Figures for 1961-68 were obtained from the U.S. Department of Education (1948-81), those for 1969-82 from the U.S. Department of Education (1948-88), those for 1983-86 from the U.S. Department of Education (1974-87). Behavioral science B.A.s include psychology, sociology, anthropology, and speech pathology/audiology. Figures are higher than those presented in the 1983 Report because speech pathology/audiology is now included in the taxonomy.

## APPENDIX TABLE C10-1. Behavioral Science Ph.D. Degrees Awarded in Colleges and Universities, by Type of Institutional Control, 1961-87 1/

| Fiscal Year | Total Behavorial Sciences | | | Total Psychology (Clinical and Nonclinical) | | | Clinical Psychology 2/ | | | Nonclinical Psychology | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Public | Private | Total | Public | Private | Total | Public | Private | Total | Public | Private |
| 1961 | 1,042 | n/a | n/a | 820 | n/a | n/a | 381 | n/a | n/a | 439 | n/a | n/a |
| 1962 | 1,121 | n/a | n/a | 856 | n/a | n/a | 362 | n/a | n/a | 494 | n/a | n/a |
| 1963 | 1,184 | n/a | n/a | 890 | n/a | n/a | 367 | n/a | n/a | 523 | n/a | n/a |
| 1964 | 1,297 | n/a | n/a | 1,013 | n/a | n/a | 469 | n/a | n/a | 544 | n/a | n/a |
| 1965 | 1,275 | n/a | n/a | 954 | n/a | n/a | 398 | n/a | n/a | 556 | n/a | n/a |
| 1966 | 1,496 | n/a | n/a | 1,139 | n/a | n/a | 439 | n/a | n/a | 700 | n/a | n/a |
| 1967 | 1,773 | n/a | n/a | 1,295 | n/a | n/a | 529 | n/a | n/a | 766 | n/a | n/a |
| 1968 | 1,970 | n/a | n/a | 1,464 | n/a | n/a | 613 | n/a | n/a | 851 | n/a | n/a |
| 1969 | 2,408 | n/a | n/a | 1,756 | n/a | n/a | 666 | n/a | n/a | 1,090 | n/a | n/a |
| 1970 | 2,726 | n/a | n/a | 1,888 | n/a | n/a | 707 | n/a | n/a | 1,181 | n/a | n/a |
| 1971 | 3,148 | n/a | n/a | 2,130 | n/a | n/a | 839 | n/a | n/a | 1,291 | n/a | n/a |
| 1972 | 3,310 | 2,121 | 1,189 | 2,280 | 1,490 | 790 | 919 | 633 | 286 | 1,361 | 857 | 504 |
| 1973 | 3,542 | 2,245 | 1,297 | 2,458 | 1,541 | 917 | 1,055 | 673 | 382 | 1,403 | 868 | 535 |
| 1974 | 3,750 | 2,358 | 1,392 | 2,598 | 1,626 | 972 | 1,061 | 653 | 408 | 1,537 | 973 | 564 |
| 1975 | 3,938 | 2,552 | 1,386 | 2,751 | 1,783 | 968 | 1,144 | 771 | 373 | 1,607 | 1,012 | 595 |
| 1976 | 4,190 | 2,673 | 1,517 | 2,883 | 1,807 | 1,076 | 1,293 | 805 | 488 | 1,590 | 1,002 | 588 |
| 1977 | 4,246 | 2,685 | 1,561 | 2,990 | 1,864 | 1,126 | 1,353 | 858 | 495 | 1,637 | 1,006 | 631 |
| 1978 | 4,207 | 2,632 | 1,575 | 3,055 | 1,853 | 1,202 | 1,464 | 880 | 584 | 1,591 | 973 | 618 |
| 1979 | 4,245 | 2,698 | 1,547 | 3,091 | 1,918 | 1,173 | 1,509 | 923 | 586 | 1,582 | 995 | 587 |
| 1980 | 4,192 | 2,517 | 1,675 | 3,098 | 1,787 | 1,311 | 1,581 | 896 | 685 | 1,517 | 891 | 626 |
| 1981 | 4,472 | 2,727 | 1,745 | 3,358 | 1,965 | 1,393 | 1,743 | 962 | 781 | 1,615 | 1,003 | 612 |
| 1982 | 4,188 | 2,541 | 1,647 | 3,158 | 1,830 | 1,328 | 1,681 | 957 | 724 | 1,477 | 873 | 604 |
| 1983 | 4,318 | 2,626 | 1,692 | 3,307 | 1,951 | 1,356 | 1,762 | 981 | 781 | 1,545 | 970 | 575 |
| 1984 | 4,184 | 2,615 | 1,569 | 3,230 | 1,990 | 1,240 | 1,726 | 1,041 | 685 | 1,504 | 949 | 555 |
| 1985 | 3,986 | 2,542 | 1,444 | 3,073 | 1,908 | 1,165 | 1,680 | 1,012 | 668 | 1,393 | 896 | 497 |
| 1986 | 4,032 | 2,560 | 1,472 | 3,077 | 1,899 | 1,178 | 1,710 | 1,003 | 707 | 1,367 | 896 | 471 |
| 1987 | 3,960 | 2,488 | 1,472 | 3,078 | 1,901 | 1,177 | 1,712 | 1,038 | 674 | 1,366 | 863 | 503 |

1/ From the National Research Council's Doctorate Records File (1958-88). Foreign nationals who received doctorates from U.S. institutions are included.

2/ Includes clinical and school psychology, counseling, and guidance.

(Data for additional fields are on the following table)

## APPENDIX TABLE C10-2. Behavioral Science Ph.D. Degrees Awarded in Colleges and Universities, by Type of Institutional Control, 1961-87 1/

|  | Total Other Behavioral Sci. (Socio.,Anthro.,Spch./Audio.) |  |  | Sociology |  |  | Anthropology |  |  | Speech Pathology/Audiology |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fiscal Year | Total | Public | Private | Total | Public | Private | Total | Public | Private | Total | Public | Private |
| 1961 | 222 | n/a | n/a | 167 | n/a | n/a | 55 | n/a | n/a | n/a | n/a | n/a |
| 1962 | 265 | n/a | n/a | 184 | n/a | n/a | 81 | n/a | n/a | n/a | n/a | n/a |
| 1963 | 293 | n/a | n/a | 211 | n/a | n/a | 82 | n/a | n/a | n/a | n/a | n/a |
| 1964 | 284 | n/a | n/a | 201 | n/a | n/a | 83 | n/a | n/a | n/a | n/a | n/a |
| 1965 | 321 | n/a | n/a | 239 | n/a | n/a | 82 | n/a | n/a | n/a | n/a | n/a |
| 1966 | 357 | n/a | n/a | 260 | n/a | n/a | 97 | n/a | n/a | n/a | n/a | n/a |
| 1967 | 478 | n/a | n/a | 331 | n/a | n/a | 147 | n/a | n/a | n/a | n/a | n/a |
| 1968 | 506 | n/a | n/a | 369 | n/a | n/a | 137 | n/a | n/a | n/a | n/a | n/a |
| 1969 | 652 | n/a | n/a | 408 | n/a | n/a | 180 | n/a | n/a | 64 | n/a | n/a |
| 1970 | 838 | n/a | n/a | 505 | n/a | n/a | 217 | n/a | n/a | 116 | n/a | n/a |
| 1971 | 1,018 | n/a | n/a | 586 | n/a | n/a | 239 | n/a | n/a | 193 | n/a | n/a |
| 1972 | 1,030 | 631 | 399 | 639 | 374 | 265 | 260 | 155 | 105 | 131 | 102 | 29 |
| 1973 | 1,084 | 704 | 380 | 599 | 369 | 230 | 326 | 211 | 115 | 159 | 124 | 35 |
| 1974 | 1,152 | 732 | 420 | 645 | 390 | 255 | 379 | 238 | 141 | 128 | 104 | 24 |
| 1975 | 1,187 | 769 | 418 | 680 | 418 | 262 | 386 | 260 | 126 | 121 | 91 | 30 |
| 1976 | 1,307 | 866 | 441 | 734 | 459 | 275 | 428 | 283 | 145 | 145 | 124 | 21 |
| 1977 | 1,256 | 821 | 435 | 725 | 452 | 273 | 385 | 254 | 131 | 146 | 115 | 31 |
| 1978 | 1,152 | 779 | 373 | 610 | 399 | 211 | 399 | 270 | 129 | 143 | 110 | 33 |
| 1979 | 1,154 | 780 | 374 | 632 | 407 | 225 | 383 | 258 | 125 | 139 | 115 | 24 |
| 1980 | 1,094 | 730 | 364 | 601 | 382 | 219 | 370 | 255 | 115 | 123 | 93 | 30 |
| 1981 | 1,114 | 762 | 352 | 605 | 407 | 198 | 369 | 238 | 131 | 140 | 117 | 23 |
| 1982 | 1,030 | 711 | 319 | 568 | 372 | 196 | 333 | 230 | 103 | 129 | 109 | 20 |
| 1983 | 1,011 | 675 | 336 | 525 | 338 | 187 | 373 | 246 | 127 | 113 | 91 | 22 |
| 1984 | 954 | 625 | 329 | 515 | 320 | 195 | 335 | 225 | 110 | 104 | 80 | 24 |
| 1985 | 913 | 634 | 279 | 461 | 305 | 156 | 353 | 248 | 105 | 99 | 81 | 18 |
| 1986 | 955 | 661 | 294 | 492 | 318 | 174 | 381 | 276 | 105 | 82 | 67 | 15 |
| 1987 | 882 | 587 | 295 | 423 | 271 | 152 | 352 | 236 | 116 | 107 | 80 | 27 |

1/ From the National Research Council (1958-88). Foreign nationals who received doctorates from U.S. institutions are included.

## APPENDIX TABLE C11-1. Behavioral Science Postdoctoral Appointments, 1973-87 1/

| | All Behavioral Fields | | | | | Clinical Psychology | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Academic 2/ | | | | | Academic 2/ | | | |
| Fiscal Year | Total | Total | Public | Private | Nonacademic | Total | Total | Public | Private | Nonacademic |
| 1973 | 482 | 320 | 195 | 125 | 162 | 125 | 46 | 28 | 18 | 79 |
| 1974 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1975 | 705 | 556 | 355 | 201 | 149 | 156 | 79 | 57 | 22 | 77 |
| 1976 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1977 | 997 | 736 | 416 | 320 | 261 | 357 | 186 | 96 | 90 | 171 |
| 1978 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1979 | 1,111 | 795 | 380 | 415 | 316 | 302 | 182 | 59 | 123 | 120 |
| 1980 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1981 | 972 | 705 | 395 | 310 | 267 | 262 | 160 | 99 | 61 | 102 |
| 1982 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1983 | 1,039 | 652 | 493 | 159 | 387 | 466 | 179 | 142 | 37 | 287 |
| 1984 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1985 | 1,622 | n/a | n/a | n/a | n/a | 774 | n/a | n/a | n/a | n/a |
| 1986 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1987 | 1,279 | n/a | n/a | n/a | n/a | 421 | n/a | n/a | n/a | n/a |

1/ Clinical psychology includes clinical and school psychology, counseling, and guidance. All other psychology fields are considered nonclinical. Other behavioral sciences include anthropology, sociology, and speech pathology/audiology. Figures are based on the most recent data available from the National Research Council's Survey of Doctorate Recipients (1973-88). Foreign nationals who received doctorates from U.S. institutions are included.

2/ Public and private figures were adjusted by the committee to include a small number of individuals for whom type of institutional control could not be determined.

(Data for additional fields are on the following table)

## APPENDIX TABLE C11-2. Behavioral Science Postdoctoral Appointments, 1973-87 1/

| | Nonclinical Psychology | | | | | Other Behavioral Sciences | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Academic 2/ | | | | | Academic 2/ | | | |
| Fiscal Year | Total | Total | Public | Private | Nonacademic | Total | Total | Public | Private | Nonacademic |
| 1973 | 259 | 197 | 127 | 70 | 62 | 98 | 77 | 40 | 37 | 21 |
| 1974 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1975 | 398 | 368 | 258 | 110 | 30 | 151 | 109 | 40 | 69 | 42 |
| 1976 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1977 | 394 | 344 | 218 | 126 | 50 | 246 | 206 | 102 | 104 | 40 |
| 1978 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1979 | 527 | 359 | 173 | 186 | 168 | 282 | 254 | 148 | 106 | 28 |
| 1980 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1981 | 511 | 379 | 174 | 205 | 132 | 199 | 166 | 122 | 44 | 33 |
| 1982 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1983 | 302 | 249 | 173 | 76 | 53 | 271 | 224 | 178 | 46 | 47 |
| 1984 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1985 | 593 | n/a | n/a | n/a | n/a | 256 | n/a | n/a | n/a | n/a |
| 1986 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1987 | 666 | n/a | n/a | n/a | n/a | 192 | n/a | n/a | n/a | n/a |

1/ Clinical psychology includes clinical and school psychology, counseling, and guidance. All other psychology fields are considered nonclinical. Other behavioral sciences include anthropology, sociology, and speech pathology/audiology. Figures are based on the most recent data available from the National Research Council's Survey of Doctorate Recipients (1973-88). Foreign nationals who received doctorates from U.S. institutions are included.

2/ Public and private figures were adjusted by the committee to include a small number of individuals for whom type of institutional control could not be determined.

## APPENDIX TABLE C12. Ph.D.s Employed in All Behavioral Science Fields, 1973-87 1/

| Fiscal Year | Total Labor Force | Academia (excl. postd) Total | Postdoc. Appts. | Business | Gov't. 3/ | Hospitals/ Clinics | Non-Profit | Self-Employed | Other | Unemployed and Seeking |
|---|---|---|---|---|---|---|---|---|---|---|
| 1973 | 31,699 | 19,928 | 482 | 1,142 | 2,845 | 2,698 | 1,246 | 1,895 | 1,075 | 388 |
| 1974 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1975 | 38,737 | 23,624 | 705 | 1,404 | 2,632 | 4,936 | 1,161 | 2,748 | 1,138 | 389 |
| 1976 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1977 | 44,283 | 25,582 | 997 | 1,793 | 2,931 | 5,595 | 1,487 | 3,725 | 1,419 | 754 |
| 1978 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1979 | 49,322 | 26,896 | 1,111 | 1,901 | 3,288 | 6,157 | 2,164 | 5,209 | 1,847 | 749 |
| 1980 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1981 | 53,815 | 28,235 | 972 | 2,764 | 3,351 | 6,481 | 2,120 | 7,352 | 1,808 | 732 |
| 1982 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1983 | 58,811 | 29,776 | 1,039 | 3,390 | 3,559 | 6,584 | 1,865 | 9,707 | 1,978 | 913 |
| 1984 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1985 | 64,253 | 31,719 | 1,622 | 3,125 | 3,281 | 7,124 | 2,166 | 12,137 | 2,269 | 810 |
| 1986 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1987 | 67,706 | 31,809 | 1,279 | 2,384 | 3,960 | 7,913 | 2,651 | 14,550 | 2,267 | 893 |

1/ Behavioral sciences include anthropology, sociology, psychology, and speech pathology/audiology.
Based on the most recent data available from the National Research Council's Survey of Doctorate Recipients (1973-88). Foreign nationals who received doctorates from U.S. institutions are included.

## APPENDIX TABLE C13. Ph.D.s Employed in Clinical Psychology, 1973-87 1/

| Fiscal Year | Total Labor Force | Total Academia (excluding postdocs.) | Postdoc. Appts. | Business | Gov't. 2/ | Hospitals/ Clinics | Non-Profit | Self-Employed | Other | Unemployed and Seeking |
|---|---|---|---|---|---|---|---|---|---|---|
| 1973 | 11,574 | 4,341 | 125 | 101 | 1,641 | 2,417 | 497 | 1,520 | 821 | 111 |
| 1974 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1975 | 14,846 | 5,140 | 156 | 165 | 1,252 | 4,425 | 363 | 2,292 | 995 | 58 |
| 1976 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1977 | 17,578 | 5,438 | 357 | 409 | 1,216 | 5,102 | 662 | 3,201 | 1,111 | 82 |
| 1978 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1979 | 21,268 | 5,790 | 302 | 417 | 1,671 | 5,702 | 1,093 | 4,785 | 1,372 | 136 |
| 1980 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1981 | 23,775 | 6,172 | 262 | 880 | 1,653 | 5,937 | 1,032 | 6,264 | 1,367 | 208 |
| 1982 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1983 | 26,285 | 6,370 | 466 | 1,004 | 1,854 | 5,737 | 1,165 | 7,999 | 1,529 | 161 |
| 1984 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1985 | 30,926 | 7,495 | 774 | 1,007 | 1,873 | 6,166 | 1,194 | 10,401 | 1,898 | 117 |
| 1986 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1987 | 33,599 | 7,997 | 421 | 410 | 1,858 | 6,950 | 1,447 | 12,440 | 1,865 | 209 |

1/ Clinical psychology includes clinical and school psychology, counseling, and guidance. Figures are based on the most recent data available from the National Research Council's Survey of Doctorate Recipients (1973-88). Foreign nationals who received doctorates from U.S. institutions are included.

2/ Includes FFRDC laboratories.

## APPENDIX TABLE C14. Ph.D.s Employed in Nonclinical Psychology, 1973-87 1/

| Fiscal Year | Total Labor Force | Total Academia (excluding postdocs.) | Postdoc. Appts. | Business | Gov't. 2/ | Hospitals/ Clinics | Non-Profit | Self-Employed | Other | Unemployed and Seeking |
|---|---|---|---|---|---|---|---|---|---|---|
| 1973 | 13,340 | 9,452 | 259 | 999 | 1,083 | 269 | 562 | 323 | 212 | 181 |
| 1974 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1975 | 15,387 | 10,863 | 398 | 1,218 | 1,170 | 470 | 560 | 401 | 129 | 178 |
| 1976 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1977 | 16,102 | 10,905 | 394 | 1,344 | 1,404 | 447 | 519 | 443 | 255 | 391 |
| 1978 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1979 | 16,688 | 11,538 | 527 | 1,355 | 1,164 | 401 | 574 | 321 | 434 | 374 |
| 1980 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1981 | 18,791 | 12,586 | 511 | 1,827 | 1,235 | 507 | 631 | 905 | 295 | 294 |
| 1982 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1983 | 19,431 | 12,404 | 302 | 2,258 | 1,320 | 629 | 451 | 1,328 | 333 | 406 |
| 1984 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1985 | 20,070 | 13,221 | 593 | 1,924 | 1,189 | 585 | 667 | 1,270 | 245 | 376 |
| 1986 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1987 | 20,755 | 13,058 | 666 | 1,745 | 1,724 | 555 | 858 | 1,655 | 249 | 246 |

1/ Nonclinical psychology includes all psychology fields except clinical and school psychology, counseling, and guidance. Figures are based on the most recent data available from the National Research Council's Survey of Doctorate Recipients (1973-88). Foreign nationals who received doctorates from U.S. institutions are included.

2/ Includes FFRDC laboratories.

## APPENDIX TABLE C15. Ph.D.s Employed in Other Behavioral Sciences, 1973-87 1/

| Fiscal Year | Total Labor Force | Total Academia (excluding postdocs.) | Postdoc. Appts. | Business | Gov't. 2/ | Hospitals/ Clinics | Non-Profit | Self-Employed | Other | Unemployed and Seeking |
|---|---|---|---|---|---|---|---|---|---|---|
| 1973 | 6,785 | 6,135 | 98 | 42 | 121 | 12 | 187 | 52 | 42 | 96 |
| 1974 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1975 | 8,504 | 7,621 | 151 | 21 | 210 | 41 | 238 | 55 | 14 | 153 |
| 1976 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1977 | 10,603 | 9,239 | 246 | 40 | 311 | 46 | 306 | 81 | 53 | 281 |
| 1978 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1979 | 11,366 | 9,568 | 282 | 129 | 453 | 54 | 497 | 103 | 41 | 239 |
| 1980 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1981 | 11,249 | 9,477 | 199 | 57 | 463 | 37 | 457 | 183 | 146 | 230 |
| 1982 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1983 | 13,095 | 11,002 | 271 | 128 | 385 | 218 | 249 | 380 | 116 | 346 |
| 1984 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1985 | 13,264 | 11,009 | 256 | 193 | 218 | 373 | 304 | 466 | 126 | 318 |
| 1986 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1987 | 13,365 | 10,767 | 192 | 229 | 379 | 408 | 346 | 455 | 152 | 438 |

1/ Other behavioral sciences include sociology, anthropology, and speech pathology/audiology. Figures are based on the most recent data available from the National Research Council's Survey of Doctorate Recipients (1973-88). Foreign nationals who received doctorates from U.S. institutions are included.

2/ Includes FFRDC laboratories.

## APPENDIX TABLE C16. Behavioral Sciences Faculty/Student Ratios, 1964-87 1/

| | All Behavioral Sciences | | | Psychology (Clinical and Nonclinical) | | | Other Behavioral Sciences (Sociology, Anthropology, Speech Pathology/Audio.) | | |
|---|---|---|---|---|---|---|---|---|---|
| Fiscal Year | Faculty (F) | 4-Yr. Weighted Avg. Enrollment (WS) | Ph.D. Faculty/ Student Ratio (F/WS) | Faculty (F) | 4-Yr. Weighted Avg. Enrollment (WS) | Ph.D. Faculty/ Student Ratio (F/WS) | Faculty (F) | 4-Yr. Weighted Avg. Enrollment (WS) | Ph.D. Faculty/ Student Ratio (F/WS) |
| 1964 | 8,143 | 244,233 | 0.0333 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1965 | n/a | 277,679 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1966 | 9,783 | 313,740 | 0.0312 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1967 | n/a | 355,859 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1968 | 12,915 | 406,997 | 0.0317 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1969 | n/a | 467,380 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1970 | 16,175 | 532,072 | 0.0304 | n/a | n/a | n/a | n/a | n/a | n/a |
| 1971 | n/a | 601,440 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1972 | n/a | 667,374 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1973 | 19,928 | 715,941 | 0.0278 | 13,793 | 383,970 | 0.0359 | 6,135 | 325,774 | 0.0188 |
| 1974 | n/a | 736,628 | n/a | n/a | 405,407 | n/a | n/a | 328,122 | n/a |
| 1975 | 23,624 | 735,024 | 0.0321 | 16,003 | 416,229 | 0.0384 | 7,621 | 318,795 | 0.0239 |
| 1976 | n/a | 728,374 | n/a | n/a | 422,571 | n/a | n/a | 305,803 | n/a |
| 1977 | 25,582 | 725,809 | 0.0352 | 16,343 | 427,619 | 0.0382 | 9,239 | 298,190 | 0.0310 |
| 1978 | n/a | 723,604 | n/a | n/a | 431,288 | n/a | n/a | 292,083 | n/a |
| 1979 | 26,896 | 712,760 | 0.0377 | 17,328 | 430,591 | 0.0402 | 9,568 | 281,484 | 0.0340 |
| 1980 | n/a | 694,840 | n/a | n/a | 427,411 | n/a | n/a | 266,318 | n/a |
| 1981 | 28,235 | 676,919 | 0.0417 | 18,758 | 426,054 | 0.0440 | 9,477 | 249,580 | 0.0380 |
| 1982 | n/a | 664,125 | n/a | n/a | 427,994 | n/a | n/a | 234,912 | n/a |
| 1983 | 29,776 | 655,212 | 0.0454 | 18,774 | 432,435 | 0.0434 | 11,002 | 221,610 | 0.0496 |
| 1984 | n/a | 648,209 | n/a | n/a | 436,661 | n/a | n/a | 210,402 | n/a |
| 1985 | 31,725 | n/a | n/a | 20,716 | n/a | n/a | 11,009 | n/a | n/a |
| 1986 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1987 | 31,822 | n/a | n/a | 21,055 | n/a | n/a | 10,767 | n/a | n/a |

1/ Faculty is defined as all Ph.D.s academically employed in the behavioral science area (excluding postdoctoral appointments). Students are defined as a 4-year weighted average of enrollments, i.e., (WS)t = 1/6(St + 2St-1 + 2St-2 + St-3), where S = total graduate and undergraduate enrollment in the behavioral science area. See Appendix Tables C1, C4-6, and C8 for supporting data.

## APPENDIX TABLE C17. Ph.D.s Academically Employed in the Behavioral Sciences, by Employment Status and Type of Institution, 1973-87 1/

|  |  | All Behavioral Fields |  |  | Clinical Psychology |  |  | Nonclinical Psychology |  |  | Other Behavioral Sciences |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Type of Institution |  |  | Type of Institution |  |  | Type of Institution |  |  | Type of Institution |  |  |
| Fiscal Year | Employment Status | Total | 4-Year | 2-Year | Total | 4-Year | 2-Year | Total | 4-Year | 2-Year | Total | 4-Year | 2-Year |
| 1973 | Total | 19,928 | 19,361 | 567 | 4,341 | 4,155 | 186 | 9,452 | 9,144 | 308 | 6,135 | 6,062 | 73 |
|  | Full-Time | 19,220 | 18,710 | 510 | 4,159 | 3,977 | 182 | 9,164 | 8,909 | 255 | 5,897 | 5,824 | 73 |
|  | Part-Time | 708 | 651 | 57 | 182 | 178 | 4 | 288 | 235 | 53 | 238 | 238 | 0 |
| 1975 | Total | 23,624 | 22,923 | 701 | 5,140 | 4,946 | 194 | 10,863 | 10,528 | 335 | 7,621 | 7,449 | 172 |
|  | Full-Time | 22,887 | 22,255 | 632 | 4,965 | 4,778 | 187 | 10,511 | 10,210 | 301 | 7,413 | 7,269 | 144 |
|  | Part-Time | 737 | 668 | 69 | 175 | 168 | 7 | 352 | 318 | 34 | 208 | 180 | 28 |
| 1977 | Total | 25,582 | 24,706 | 876 | 5,438 | 5,272 | 166 | 10,905 | 10,438 | 467 | 9,239 | 8,996 | 243 |
|  | Full-Time | 24,736 | 23,970 | 766 | 5,233 | 5,074 | 159 | 10,505 | 10,124 | 381 | 8,998 | 8,772 | 226 |
|  | Part-Time | 846 | 736 | 110 | 205 | 198 | 7 | 400 | 314 | 86 | 241 | 224 | 17 |
| 1979 | Total | 26,896 | 26,003 | 893 | 5,790 | 5,621 | 169 | 11,538 | 11,090 | 448 | 9,568 | 9,292 | 276 |
|  | Full-Time | 25,566 | 24,836 | 730 | 5,463 | 5,318 | 145 | 10,966 | 10,619 | 347 | 9,137 | 8,898 | 239 |
|  | Part-Time | 1,330 | 1,167 | 163 | 327 | 303 | 24 | 572 | 471 | 101 | 431 | 394 | 37 |
| 1981 | Total | 28,235 | 27,062 | 1,173 | 6,172 | 5,806 | 366 | 12,586 | 12,062 | 524 | 9,477 | 9,194 | 283 |
|  | Full-Time | 27,098 | 26,065 | 1,033 | 5,802 | 5,464 | 338 | 12,181 | 11,744 | 437 | 9,111 | 8,854 | 257 |
|  | Part-Time | 1,137 | 997 | 140 | 370 | 342 | 28 | 405 | 318 | 87 | 366 | 340 | 26 |
| 1983 | Total | 29,776 | 28,487 | 1,289 | 6,370 | 6,151 | 219 | 12,404 | 11,772 | 632 | 11,002 | 10,564 | 438 |
|  | Full-Time | 28,091 | 26,964 | 1,127 | 5,903 | 5,684 | 219 | 11,871 | 11,315 | 556 | 10,317 | 9,964 | 353 |
|  | Part-Time | 1,685 | 1,523 | 162 | 467 | 467 | 0 | 533 | 457 | 76 | 685 | 600 | 85 |
| 1985 | Total | 31,719 | 30,296 | 1,423 | 7,499 | 7,142 | 357 | 13,222 | 12,545 | 677 | 11,009 | 10,619 | 390 |
|  | Full-Time | 30,004 | 28,751 | 1,253 | 7,082 | 6,739 | 343 | 12,617 | 12,040 | 577 | 10,315 | 9,980 | 335 |
|  | Part-Time | 1,715 | 1,545 | 170 | 417 | 403 | 14 | 605 | 505 | 100 | 694 | 639 | 55 |
| 1987 | Total | 31,809 | 30,411 | 1,398 | 8,000 | 7,654 | 346 | 13,060 | 12,401 | 659 | 10,767 | 10,371 | 396 |
|  | Full-Time | 29,975 | 28,738 | 1,237 | 7,550 | 7,253 | 297 | 12,431 | 11,822 | 609 | 10,010 | 9,677 | 333 |
|  | Part-Time | 1,834 | 1,673 | 161 | 450 | 401 | 49 | 629 | 579 | 50 | 757 | 694 | 63 |
| Average | Total | 3.4% | 3.3% | 6.7% | 4.5% | 4.5% | 4.5% | 2.3% | 2.2% | 5.6% | 4.1% | 3.9% | 12.8% |
| Annual Growth | Full-Time | 3.2% | 3.1% | 6.5% | 4.4% | 4.4% | 3.6% | 2.2% | 2.0% | 6.4% | 3.9% | 3.7% | 11.5% |
| Rate 1973-87 | Part-Time | 7.0% | 7.0% | 7.7% | 6.7% | 6.0% | 19.6% | 5.7% | 6.7% | -0.4% | 8.6% | 7.9% |  |

1/ Clinical psychology includes clinical and school psychology, counseling, and guidance. All other psychology fields are considered nonclinical. Other behavioral sciences include anthropology, sociology, and speech pathology/audiology. Figures are based on the most recent data available from the National Research Council (1973-88). Foreign nationals who received doctorates from U.S. institutions are included. Individuals on postdoctoral appointments are excluded.

## APPENDIX TABLE C18. Behavioral Science R and D Expenditures, by Type of Institutional Control, 1964-87 ($ millions)

| Fiscal Year | Current Dollars 1/ | | | 1972 Dollars | | | Implicit GNP Price Deflator 2/ (1972 = 100.0) |
|---|---|---|---|---|---|---|---|
| | Total | Public | Private | Total | Public | Private | |
| 1964 | 46.6 | n/a | n/a | 64.1 | n/a | n/a | 72.70 |
| 1965 | n/a | n/a | n/a | n/a | n/a | n/a | 74.30 |
| 1966 | 60.1 | n/a | n/a | 78.3 | n/a | n/a | 76.80 |
| 1967 | n/a | n/a | n/a | n/a | n/a | n/a | 79.00 |
| 1968 | 97.9 | n/a | n/a | 118.5 | n/a | n/a | 82.60 |
| 1969 | n/a | n/a | n/a | n/a | n/a | n/a | 86.70 |
| 1970 | 103.6 | n/a | n/a | 113.3 | n/a | n/a | 91.40 |
| 1971 | n/a | n/a | n/a | n/a | n/a | n/a | 96.00 |
| 1972 | 127.6 | 84.3 | 43.4 | 127.6 | 84.3 | 43.4 | 100.00 |
| 1973 | 135.3 | 92.6 | 42.7 | 127.9 | 87.5 | 40.4 | 105.80 |
| 1974 | 137.7 | 95.0 | 42.7 | 118.7 | 81.9 | 36.8 | 116.00 |
| 1975 | 149.1 | 103.4 | 45.7 | 117.2 | 81.3 | 35.9 | 127.20 |
| 1976 | 144.1 | 99.6 | 44.5 | 107.6 | 74.4 | 33.2 | 133.90 |
| 1977 | 147.1 | 99.2 | 47.8 | 103.8 | 70.0 | 33.7 | 141.70 |
| 1978 | 156.6 | 107.3 | 49.3 | 103.0 | 70.6 | 32.4 | 152.05 |
| 1979 | 175.2 | 120.8 | 54.4 | 105.9 | 73.0 | 32.9 | 165.46 |
| 1980 | 199.1 | 137.9 | 61.1 | 111.6 | 77.3 | 34.2 | 178.42 |
| 1981 | 223.2 | 155.4 | 67.8 | 114.4 | 79.6 | 34.7 | 195.14 |
| 1982 | 212.1 | 138.3 | 73.8 | 102.5 | 66.9 | 35.7 | 206.88 |
| 1983 | 215.3 | 144.7 | 70.6 | 99.8 | 67.1 | 32.7 | 215.63 |
| 1984 | 218.7 | 141.2 | 77.5 | 97.9 | 63.2 | 34.7 | 223.43 |
| 1985 | 235.3 | 154.4 | 80.9 | 101.9 | 66.9 | 35.1 | 230.80 |
| 1986 | 257.4 | 167.2 | 90.2 | 108.6 | 70.5 | 38.1 | 237.04 |
| 1987 | 275.7 | 174.8 | 100.9 | 112.6 | 71.4 | 41.2 | 244.86 |

1/ Figures for even years from 1964-70 and for all years from 1972-87 were obtained from the National Science Foundation (1975-88). The 1978 figures are NSF estimates. Items may not sum to totals due to rounding.

2/ From the U.S. Bureau of the Census (1988a,b).

## APPENDIX TABLE C19. Average Behavioral Science R and D Expenditures per School in Colleges and Universities, by Type of Institutional Control, 1972-87 (1972 $, thousands)

| Fiscal Year | Average R and D Expenditures | | | Number of Schools Reporting 2/ | | |
|---|---|---|---|---|---|---|
| | Total | Public | Private | Total | Public | Private |
| 1972 | 216 | 252 | 170 | 591 | 335 | 256 |
| 1973 | 216 | 261 | 158 | 591 | 335 | 256 |
| 1974 | 199 | 244 | 142 | 596 | 336 | 260 |
| 1975 | 219 | 252 | 169 | 536 | 323 | 213 |
| 1976 | 201 | 231 | 156 | 535 | 322 | 213 |
| 1977 | 194 | 217 | 158 | 536 | 322 | 214 |
| 1978 | 183 | 213 | 140 | 562 | 331 | 231 |
| 1979 | 187 | 220 | 141 | 565 | 332 | 233 |
| 1980 | 198 | 233 | 148 | 563 | 332 | 231 |
| 1981 | 203 | 240 | 150 | 563 | 332 | 231 |
| 1982 | 182 | 201 | 154 | 563 | 332 | 231 |
| 1983 | 178 | 203 | 142 | 562 | 331 | 231 |
| 1984 | 174 | n/a | n/a | 561 | n/a | n/a |
| 1985 | 182 | n/a | n/a | 561 | n/a | n/a |
| 1986 | 194 | n/a | n/a | 561 | n/a | n/a |
| 1987 | 200 | n/a | n/a | 562 | n/a | n/a |

1/ See Appendix Table C18 for supporting data.

2/ From the National Science Foundation. For 1978 the number of doctorate-granting institutions was obtained from NSF; the number of master's-granting institutions was estimated by the committee. Beginning in FY 1984, data were collected from a sample of 400 institutions and inflated to produce universe estimates.

## APPENDIX TABLE C20. Psychology R and D Expenditures in Colleges and Universities, by Type of Institutional Control, 1964-87

| Fiscal Year | Current Dollars (millions) 1/ | | | 1972 Dollars (millions) 2/ | | | Average R and D Expenditures per School (1972 $, thousands)3/ | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | Public | Private | Total | Public | Private | Total | Public | Private |
| 1964 | 31.904 | n/a | n/a | 43.884 | n/a | n/a | n/a | n/a | n/a |
| 1965 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1966 | 40.143 | n/a | n/a | 52.270 | n/a | n/a | n/a | n/a | n/a |
| 1967 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1968 | 59.286 | n/a | n/a | 71.775 | n/a | n/a | n/a | n/a | n/a |
| 1969 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1970 | 59.250 | n/a | n/a | 64.825 | n/a | n/a | n/a | n/a | n/a |
| 1971 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1972 | 69.025 | 46.015 | 23.010 | 69.025 | 46.015 | 23.010 | 117 | 137 | 90 |
| 1973 | 73.742 | 47.503 | 26.239 | 69.699 | 44.899 | 24.801 | 118 | 134 | 97 |
| 1974 | 74.236 | 48.920 | 25.316 | 63.997 | 42.172 | 21.824 | 107 | 126 | 84 |
| 1975 | 80.322 | 55.416 | 24.906 | 63.146 | 43.566 | 19.580 | 118 | 135 | 92 |
| 1976 | 77.883 | 51.871 | 26.012 | 58.165 | 38.739 | 19.426 | 109 | 120 | 91 |
| 1977 | 85.129 | 55.011 | 30.118 | 60.077 | 38.822 | 21.255 | 112 | 121 | 99 |
| 1978 | 89.664 | 57.453 | 32.211 | 58.970 | 37.786 | 21.184 | 105 | 114 | 92 |
| 1979 | 100.531 | 63.984 | 36.547 | 60.758 | 38.670 | 22.088 | 108 | 116 | 95 |
| 1980 | 111.084 | 71.920 | 39.164 | 62.260 | 40.309 | 21.950 | 111 | 121 | 95 |
| 1981 | 128.738 | 85.747 | 42.991 | 65.972 | 43.941 | 22.031 | 118 | 132 | 95 |
| 1982 | 132.272 | 86.374 | 45.898 | 63.937 | 41.751 | 22.186 | 115 | 126 | 96 |
| 1983 | 136.850 | 90.538 | 46.312 | 63.465 | 41.988 | 21.478 | 113 | 127 | 93 |
| 1984 | 144.712 | 93.470 | 51.241 | 64.768 | 41.834 | 22.934 | 115 | n/a | n/a |
| 1985 | 157.652 | 104.589 | 53.062 | 68.307 | 45.316 | 22.990 | 122 | n/a | n/a |
| 1986 | 169.543 | 111.541 | 58.002 | 71.525 | 47.056 | 24.469 | 127 | n/a | n/a |
| 1987 | 187.637 | 121.206 | 66.431 | 76.630 | 49.500 | 27.130 | 136 | n/a | n/a |

1/ Figures for even years from 1964-70 and for all years from 1972-87 were obtained from the National Science Foundation (1975-88). The 1978 figures are NSF estimates.
Items may not sum to totals due to rounding.

2/ 1972 dollars were obtained by using the Implicit GNP Price Deflator (U.S. Bureau of the Census -- see Appendix Table A7). Items may not sum to totals due to rounding.

3/ See Appendix Table C19 for number of schools reporting.

## APPENDIX TABLE C21. Sociology R and D Expenditures in Colleges and Universities, by Type of Institutional Control, 1964-87

| Fiscal Year | Current Dollars (millions) 1/ | | | 1972 Dollars (millions) 2/ | | | Average R&D Expenditures per School (1972 $, thousands) 3/ | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | Public | Private | Total | Public | Private | Total | Public | Private |
| 1964 | 14.664 | n/a | n/a | 20.171 | n/a | n/a | n/a | n/a | n/a |
| 1965 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1966 | 20.000 | n/a | n/a | 26.042 | n/a | n/a | n/a | n/a | n/a |
| 1967 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1968 | 38.587 | n/a | n/a | 46.715 | n/a | n/a | n/a | n/a | n/a |
| 1969 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1970 | 44.383 | n/a | n/a | 48.559 | n/a | n/a | n/a | n/a | n/a |
| 1971 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1972 | 57.983 | 37.822 | 20.161 | 57.983 | 37.822 | 20.161 | 98 | 113 | 79 |
| 1973 | 61.514 | 45.072 | 16.442 | 58.142 | 42.601 | 15.541 | 98 | 127 | 61 |
| 1974 | 63.447 | 46.054 | 17.393 | 54.696 | 39.702 | 14.994 | 92 | 118 | 58 |
| 1975 | 68.749 | 47.960 | 20.789 | 54.048 | 37.704 | 16.344 | 101 | 117 | 77 |
| 1976 | 66.239 | 47.720 | 18.519 | 49.469 | 35.639 | 13.830 | 92 | 111 | 65 |
| 1977 | 61.922 | 44.225 | 17.697 | 43.699 | 31.210 | 12.489 | 82 | 97 | 58 |
| 1978 | 66.900 | 49.857 | 17.043 | 43.999 | 32.790 | 11.209 | 78 | 99 | 49 |
| 1979 | 74.641 | 56.815 | 17.826 | 45.111 | 34.338 | 10.774 | 80 | 103 | 46 |
| 1980 | 87.992 | 66.025 | 21.967 | 49.317 | 37.005 | 12.312 | 88 | 111 | 53 |
| 1981 | 94.414 | 69.609 | 24.805 | 48.383 | 35.671 | 12.711 | 86 | 107 | 55 |
| 1982 | 79.821 | 51.927 | 27.894 | 38.583 | 25.100 | 13.483 | 69 | 76 | 58 |
| 1983 | 78.440 | 54.179 | 24.261 | 36.377 | 25.126 | 11.251 | 65 | 76 | 49 |
| 1984 | 74.030 | 47.754 | 26.276 | 33.133 | 21.373 | 11.760 | 59 | n/a | n/a |
| 1985 | 77.633 | 49.780 | 27.854 | 33.636 | 21.568 | 12.068 | 60 | n/a | n/a |
| 1986 | 87.857 | 55.665 | 32.192 | 37.064 | 23.483 | 13.581 | 66 | n/a | n/a |
| 1987 | 88.040 | 53.555 | 34.485 | 35.955 | 21.872 | 14.084 | 64 | n/a | n/a |

1/ Figures for even years from 1964-70 and for all years from 1972-87 were obtained from the National Science Foundation (1975-88). The 1978 figures are NSF estimates. Items may not sum to totals due to rounding.

2/ 1972 dollars were obtained by using the Implicit GNP Price Deflator (U.S. Bureau of the Census--see Appendix Table A7). Items may not sum to totals due to rounding.

3/ See Appendix Table C19 for number of schools reporting.

## APPENDIX TABLE C22. Graduate Enrollment in the Behavioral Sciences by Sex, 1967-88 (percent of field total) 1/

| Fiscal Year | All Behavioral Sci. | | Psychology | | Sociology | | Anthropology | | Socio./Anthro. 2/ | | Speech.Path./ Audio. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| 1967 | 68.4 | 31.6 | 70.2 | 29.8 | 66.8 | 33.2 | 62.3 | 37.7 | | | | |
| 1968 | 67.0 | 33.0 | 67.6 | 32.4 | 67.6 | 32.4 | 61.6 | 38.4 | | | | |
| 1969 | 64.9 | 35.1 | 66.2 | 33.8 | 64.4 | 35.6 | 58.6 | 41.4 | | | | |
| 1970 | 64.1 | 35.9 | 65.6 | 34.4 | 63.4 | 36.6 | 57.2 | 42.8 | | | | |
| 1971 | 62.6 | 37.4 | 63.5 | 36.5 | 62.6 | 37.4 | 57.8 | 42.2 | | | | |
| 1972 | 59.9 | 40.1 | 63.4 | 36.6 | 61.9 | 38.1 | 58.3 | 41.7 | | | 22.6 | 77.4 |
| 1973 | 58.0 | 42.0 | 61.6 | 38.4 | 60.4 | 39.6 | 56.9 | 43.1 | | | 21.3 | 78.7 |
| 1974 | 55.8 | 44.2 | 60.1 | 40.0 | 59.6 | 40.4 | 54.0 | 46.0 | | | 20.8 | 79.2 |
| 1975 | 52.4 | 47.6 | 57.4 | 42.6 | 58.0 | 42.0 | 52.9 | 47.1 | | | 16.8 | 83.2 |
| 1976 | 50.3 | 49.7 | 55.2 | 44.8 | 56.4 | 43.6 | 52.9 | 47.1 | | | 15.6 | 84.4 |
| 1977 | 47.8 | 52.2 | 52.8 | 47.2 | 54.1 | 45.9 | 50.0 | 50.0 | | | 13.2 | 86.8 |
| 1978 | 49.4 | 50.6 | 53.1 | 46.9 | 54.5 | 45.5 | 50.3 | 49.7 | 64.4 | 35.6 | 23.0 | 77.0 |
| 1979 | 47.3 | 52.7 | 50.9 | 49.1 | 53.3 | 46.7 | 49.6 | 50.4 | 59.3 | 40.7 | 19.9 | 80.1 |
| 1980 | 45.2 | 54.8 | 48.8 | 51.2 | 52.0 | 48.0 | 48.9 | 51.1 | 53.6 | 46.4 | 16.9 | 83.1 |
| 1981 | 43.2 | 56.8 | 46.8 | 53.2 | 49.8 | 50.2 | 47.6 | 52.4 | 53.7 | 46.3 | 15.2 | 84.7 |
| 1982 | 40.7 | 59.3 | 44.0 | 56.0 | 48.4 | 51.6 | 45.6 | 54.4 | 49.0 | 51.0 | 13.8 | 86.2 |
| 1983 | 39.3 | 60.7 | 42.4 | 57.6 | 46.6 | 53.4 | 45.0 | 55.0 | 48.8 | 51.2 | 14.0 | 86.0 |
| 1984 | 38.0 | 62.0 | 40.6 | 59.4 | 47.0 | 53.0 | 43.2 | 56.8 | 48.8 | 51.2 | 13.4 | 86.6 |
| 1985 | 37.2 | 62.8 | 38.8 | 61.2 | 46.5 | 53.5 | 43.7 | 56.3 | 46.2 | 53.8 | 14.8 | 85.2 |
| 1986 | 36.5 | 63.5 | 37.7 | 62.3 | 47.1 | 52.9 | 44.7 | 55.3 | 44.8 | 55.2 | 14.4 | 85.6 |
| 1987 | 35.2 | 64.8 | 36.6 | 63.3 | 45.5 | 54.5 | 42.6 | 57.4 | 43.4 | 56.6 | 12.5 | 87.5 |
| 1988 | 35.2 | 64.8 | 37.1 | 62.9 | 44.8 | 55.2 | 43.8 | 56.2 | 44.9 | 55.1 | 10.1 | 89.9 |

1/ Percents for 1967-77 are based on figures from the U.S. Department of Education (1959-79). Those for 1978-88 based on figures from the National Science Foundation (1973-88). See Appendix Tables C1 and C4-8 for supporting data.

2/ This interdisciplinary field is reported separately from sociology and anthropology by the National Science Foundation.

## APPENDIX TABLE C23. Graduate School Attrition Rates in the Behavioral Sciences, 1963-74

| Fiscal Year of Graduate School Entry | First-Year Graduate Enrollment in the Behavl. Sci. 1/ | Number of FY 1962-87 Behavioral Sci. Ph.D.s Entering Grad. School 2/ | Ph.D. Completion Rate (%) 3/ | Graduate School Attrition Rate (%) 3/ |
|---|---|---|---|---|
| Pre-1963 | | 16,636 | | |
| Post-1974 | | 19,876 | | |
| 1963 | 8,739 | 2,457 | 28.1 | 71.9 |
| 1964 | 9,288 | 2,918 | 31.4 | 68.6 |
| 1965 | 11,832 | 3,358 | 28.4 | 71.6 |
| 1966 | 13,659 | 3,797 | 27.8 | 72.2 |
| 1967 | 13,659 | 4,050 | 29.7 | 70.3 |
| 1968 | 15,966 | 4,017 | 25.2 | 74.8 |
| 1969 | 16,831 | 4,034 | 24.0 | 76.0 |
| 1970 | 19,501 | 4,551 | 23.3 | 76.7 |
| 1971 | 22,709 | 4,751 | 20.9 | 79.1 |
| 1972 | 24,607 | 4,797 | 19.5 | 80.5 |
| 1973 | 26,269 | 4,659 | 17.7 | 82.3 |
| 1974 | 27,636 | 4,356 | 15.8 | 84.2 |

1/From the U.S. Department of Education (1959-79).

2/From the National Research Council's Doctorate Records File (1958-88).

3/The Ph.D. completion rate represents the percentage of first-year graduate students in a given year who earned a Ph.D. between 1962 and 1987 (column 2/column 1). The attrition rate is obtained by subtracting the Ph.D. completion rate for a given year from 100.0%. The rates for 1960-64 are relatively constant (see 1985 Report), i that most individuals entering graduate school during that period had either received a Ph.D. or dropped out of graduate school by 1987. For later years, the Ph.D. completion rates decline with each year. The attrition rates for these years undoubtedly include students who are still enrolled in graduate school but who had not earned a Ph.D. by 1987, as well as those who had actually dropped out of graduate school. The median elapsec from baccalaureate to bioscience doctorate degree in 1987 was 8.1 years; it is therefore probable that many of t graduate students entering in years after 1980 are still working toward a doctorate degree. Completion and attriti rates have not been calculated for the later years. The Ph.D. completion rates will most likely increase and the a rates decrease once 1988 Ph.D.s are added to the calculations, and should continue to do so with the inclusion c each additional year of Ph.D.s.

## APPENDIX TABLE D1. Estimates of the Total Population of the United States by Age Group, 1971-2081 (in thousands) 1/

| Fiscal Year | Age Group<br>15-19 Years | <br>20-24 Years | <br>25-29 Years |
|---|---|---|---|
| 1971 | 19,333 | 17,202 | 13,736 |
| 1972 | 19,789 | 18,159 | 14,041 |
| 1973 | 20,296 | 18,153 | 15,240 |
| 1974 | 20,719 | 18,521 | 15,786 |
| 1975 | 21,042 | 18,975 | 16,521 |
| 1976 | 21,285 | 19,527 | 17,280 |
| 1977 | 21,534 | 19,986 | 18,274 |
| 1978 | 21,540 | 20,499 | 18,277 |
| 1979 | 21,496 | 20,946 | 18,683 |
| 1980 | 21,402 | 21,297 | 19,178 |
| 1981 | 21,159 | 21,584 | 19,804 |
| 1982 | 20,556 | 21,821 | 20,306 |
| 1983 | 19,939 | 21,807 | 20,865 |
| 1984 | 19,313 | 21,700 | 21,321 |
| 1985 | 18,823 | 21,536 | 21,661 |
| 1986 | 18,587 | 21,214 | 21,892 |
| 1987 | 18,648 | 20,608 | 22,132 |
| (Projected - Middle Series) | | | |
| 1988 | 18,497 | 19,982 | 22,106 |
| 1989 | 18,248 | 19,374 | 22,008 |
| 1990 | 17,830 | 18,915 | 21,830 |
| 1991 | 17,418 | 18,689 | 21,511 |
| 1996 | 17,567 | 17,482 | 18,966 |
| 2001 | 19,112 | 17,600 | 17,736 |
| 2006 | 19,477 | 19,109 | 17,822 |
| 2011 | 18,839 | 19,453 | 19,310 |
| 2016 | 17,930 | 18,818 | 19,642 |
| 2021 | 17,642 | 17,931 | 19,020 |
| 2026 | 17,940 | 17,657 | 18,144 |
| 2031 | 18,278 | 17,962 | 17,878 |
| 2036 | 18,183 | 18,299 | 18,181 |
| 2041 | 17,769 | 18,208 | 18,516 |
| 2046 | 17,415 | 17,800 | 18,423 |
| 2051 | 17,304 | 17,450 | 18,013 |
| 2056 | 17,315 | 17,344 | 17,666 |
| 2061 | 17,235 | 17,361 | 17,564 |
| 2066 | 16,997 | 17,289 | 17,585 |
| 2071 | 16,737 | 17,059 | 17,515 |
| 2076 | 16,572 | 16,806 | 17,287 |
| 2081 | 16,480 | 16,647 | 17,036 |

1/ From the U.S. Bureau of the Census (1965-88). Includes armed forces overseas.

## APPENDIX TABLE D2. NIH/ADAMHA/HRSA Expenditures for Research Training Programs, 1971-88 ($ millions)

| | Total NIH/ADAMHA/HRSA | | | | | | NIH 1/ | | | | | ADAMHA 2/ | | | | | HRSA, Division of Nursing 3/ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total Amount | | Fellowships | | Training Grants | | Total Amount | Fellowships | | Training Grants | | Total Amount | Fellowships | | Training Grants | | Total Amount | Fellowships | | Training Grants | |
| Fiscal Year | Current $ | Constant 1972 $ 4/ | No. | Amt. | No. | Amt. | Current $ | No. | Amt. | No. | Amt. | Current $ | No. | Amt. | No. | Amt. | Current $ | No. | Amt. | No. | Amt. |
| 1971 | 171.5 | 178.6 | n/a | n/a | n/a | n/a | 152.9 | 2,718 | 23.8 | 2,111 | 129.1 | 16.7 | n/a | n/a | n/a | n/a | 1.90 | 183 | 0.90 | 9 | 1.00 |
| 1972 | 178.1 | 178.1 | n/a | n/a | n/a | n/a | 157.6 | 2,264 | 21.5 | 2,024 | 136.1 | 19.2 | n/a | n/a | n/a | n/a | 1.30 | 146 | 0.60 | 9 | 0.70 |
| 1973 | 127.2 | 120.2 | n/a | n/a | n/a | n/a | 115.3 | 1,233 | 12.2 | 1,696 | 103.1 | 10.3 | n/a | n/a | n/a | n/a | 1.60 | 136 | 0.60 | 10 | 1.00 |
| 1974 | 207.9 | 179.2 | n/a | n/a | n/a | n/a | 186.5 | 2,267 | 30.6 | 2,922 | 155.9 | 20.1 | n/a | n/a | n/a | n/a | 1.30 | 115 | 0.60 | 9 | 0.70 |
| 1975 | 177.1 | 139.2 | 2,657 | 34.1 | 1,979 | 143.0 | 156.8 | 2,056 | 27.8 | 1,739 | 129.0 | 19.7 | 570 | 6.1 | 232 | 13.6 | 0.60 | 31 | 0.20 | 8 | 0.40 |
| 1976 | 141.6 | 105.7 | 2,107 | 27.9 | 1,570 | 113.7 | 122.0 | 1,652 | 23.2 | 1,339 | 98.8 | 19.4 | 414 | 4.6 | 230 | 14.8 | 0.16 | 41 | 0.08 | 1 | 0.08 |
| 1977 | 150.6 | 106.3 | 2,389 | 31.2 | 1,436 | 119.4 | 131.6 | 1,975 | 27.3 | 1,210 | 104.3 | 18.2 | 318 | 3.3 | 223 | 14.9 | 0.80 | 96 | 0.60 | 3 | 0.20 |
| 1978 | 166.4 | 109.4 | 2,423 | 32.8 | 1,560 | 133.6 | 148.5 | 2,070 | 29.7 | 1,330 | 118.8 | 16.9 | 231 | 2.3 | 227 | 14.6 | 1.00 | 122 | 0.80 | 3 | 0.20 |
| 1979 | 167.5 | 101.2 | 2,539 | 34.9 | 1,475 | 132.6 | 149.3 | 2,208 | 31.8 | 1,265 | 117.5 | 17.2 | 219 | 2.3 | 207 | 14.9 | 1.00 | 112 | 0.80 | 3 | 0.20 |
| 1980 | 203.8 | 114.2 | 2,258 | 42.4 | 1,728 | 161.4 | 182.8 | 1,973 | 38.9 | 1,515 | 143.9 | 20.0 | 190 | 2.8 | 210 | 17.2 | 0.99 | 95 | 0.70 | 3 | 0.30 |
| 1981 | 203.5 | 104.3 | 2,072 | 39.4 | 1,570 | 164.1 | 181.7 | 1,752 | 35.5 | 1,369 | 146.2 | 20.8 | 205 | 3.0 | 200 | 17.8 | 0.99 | 115 | 0.90 | 1 | 0.10 |
| 1982 | 174.4 | 84.3 | 1,997 | 34.2 | 1,474 | 140.1 | 156.3 | 1,726 | 31.2 | 1,294 | 125.1 | 17.1 | 151 | 2.1 | 180 | 15.0 | 0.96 | 120 | 0.90 | 0 | 0.00 |
| 1983 | 189.2 | 87.7 | 2,023 | 37.6 | 1,520 | 151.5 | 171.1 | 1,756 | 34.4 | 1,340 | 136.7 | 17.1 | 155 | 2.3 | 180 | 14.8 | 0.96 | 112 | 0.90 | 0 | 0.00 |
| 1984 | 191.4 | 85.6 | 2,047 | 37.9 | 1,533 | 153.5 | 173.2 | 1,759 | 34.4 | 1,360 | 138.8 | 17.2 | 171 | 2.5 | 173 | 14.7 | 0.96 | 117 | 1.00 | 0 | 0.00 |
| 1985 | 245.7 | 106.4 | 2,313 | 51.3 | 1,527 | 195.4 | 223.9 | 1,985 | 46.4 | 1,356 | 177.5 | 20.8 | 162 | 2.9 | 171 | 17.9 | 0.96 | 166 | 2.00 | n/a | n/a |
| 1986 | 237.0 | 100.0 | 1,986 | 45.7 | 1,498 | 191.3 | 217.2 | 1,823 | 42.8 | 1,334 | 174.4 | 19.8 | 163 | 2.9 | 164 | 16.9 | | | | | |
| 1987 | 262.3 | 107.1 | 2,240 | 50.0 | 1,552 | 212.3 | 238.7 | 2,032 | 46.6 | 1,372 | 192.1 | 23.6 | 208 | 3.4 | 180 | 20.2 | | | | | |
| 1988 | | | | | | | 245.6 | 1,944 | 45.0 | 1,404 | 200.6 | | | | | | | | | | |

1/ From NIH (1966-87, 1988 edition and pre-publication data). Includes MARC Honors Undergraduate trainees.

2/ Figures for 1971-74 were obtained from ADAMHA (1978-81, 1980 edition, p. 33); figures for 1975-87 were from special tabulations prepared annually by ADAMHA, Office of the Administrator. Includes MARC Honors Undergraduate trainees.

3/ From HRSA, Division of Nursing, and NCNR. Figures for 1971-76 represent Special Nurse Research Fellowship and Nurse Scientist Training Grant Programs. Figures for 1977-85 were obtained from HRSA, Division of Nursing. Authority for NRSA research training programs in the Division of Nursing began in FY 1977; the program was transferred to NCNR/NIH in FY 1986. As a result, nursing research training awards are included in NIH training award data beginning with 1986. The 1988 NIH Data Book indicates that NCNR research training awards (in millions) were $1.0 in 1986 and $2.1 in 1987.

4/ Obtained by using the Implicit GNP Price Deflator (U.S. Bureau of the Census -- see Appendix Table A7).

## APPENDIX TABLE D3. NRSA Training Expenditures as a Percentage of NIH/ADAMHA/HRSA Research Obligations, 1971-88 ($ millions) 1/

| | Total NIH/ADAMHA/HRSA | | | NIH 2/ | | | ADAMHA 3/ | | | HRSA, Division of Nursing 4/ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fiscal Year | Research $ | Training $ | % of Research $ | Research $ | Training $ | % of Research $ | Research $ | Training $ | % of Research $ | Research $ | Training $ | % of Research $ |
| 1971 | 960.7 | 171.5 | 17.9 | 842.7 | 152.9 | 18.1 | 116.0 | 16.7 | 14.4 | 2.0 | 1.90 | 95.0 |
| 1972 | 1,173.8 | 178.1 | 15.2 | 1,041.1 | 157.6 | 15.1 | 130.3 | 19.2 | 14.7 | 2.4 | 1.30 | 54.2 |
| 1973 | 1,205.6 | 127.2 | 10.6 | 1,081.4 | 115.3 | 10.7 | 121.7 | 10.3 | 8.5 | 2.5 | 1.60 | 64.0 |
| 1974 | 1,607.2 | 207.9 | 12.9 | 1,449.3 | 186.5 | 12.9 | 155.3 | 20.1 | 12.9 | 2.6 | 1.30 | 50.0 |
| 1975 | 1,679.4 | 177.1 | 10.5 | 1,536.9 | 156.8 | 10.2 | 139.1 | 19.7 | 14.2 | 3.4 | 0.60 | 17.6 |
| 1976 | 1,854.2 | 141.6 | 7.6 | 1,678.2 | 122.0 | 7.3 | 173.2 | 19.4 | 11.2 | 2.8 | 0.16 | 5.7 |
| 1977 | 1,966.0 | 150.6 | 7.7 | 1,808.2 | 131.6 | 7.3 | 152.8 | 18.2 | 11.9 | 5.0 | 0.80 | 16.0 |
| 1978 | 2,201.0 | 166.4 | 7.6 | 2,034.7 | 148.5 | 7.3 | 161.3 | 16.9 | 10.5 | 5.0 | 1.00 | 20.0 |
| 1979 | 2,562.6 | 167.5 | 6.5 | 2,361.7 | 149.3 | 6.3 | 196.0 | 17.2 | 8.8 | 4.9 | 1.00 | 20.4 |
| 1980 | 2,759.0 | 203.8 | 7.4 | 2,542.3 | 182.8 | 7.2 | 211.7 | 20.0 | 9.4 | 5.0 | 1.00 | 20.0 |
| 1981 | 2,872.6 | 203.5 | 7.1 | 2,660.9 | 181.7 | 6.8 | 206.7 | 20.8 | 10.1 | 5.0 | 1.00 | 20.0 |
| 1982 | 2,916.6 | 174.5 | 6.0 | 2,710.7 | 156.3 | 5.8 | 202.5 | 17.2 | 8.5 | 3.4 | 1.00 | 29.4 |
| 1983 | 3,244.7 | 189.2 | 5.8 | 3,006.5 | 171.1 | 5.7 | 233.2 | 17.1 | 7.3 | 5.0 | 1.00 | 20.0 |
| 1984 | 3,687.9 | 191.3 | 5.2 | 3,405.9 | 173.2 | 5.1 | 273.1 | 17.2 | 6.3 | 8.9 | 0.90 | 10.1 |
| 1985 | 4,247.6 | 247.0 | 5.8 | 3,930.0 | 224.0 | 5.7 | 308.3 | 20.8 | 6.7 | 9.3 | 2.20 | 23.7 |
| 1986 | 4,372.5 | 236.9 | 5.4 | 4,043.4 | 217.1 | 5.4 | 329.1 | 19.8 | 6.0 | | | |
| 1987 | 5,227.8 | 262.5 | 5.0 | 4,816.5 | 238.8 | 5.0 | 411.3 | 23.7 | 5.8 | | | |
| 1988 | n/a | n/a | n/a | 5,166.9 | 245.7 | 4.8 | n/a | n/a | n/a | | | |

1/ Research obligations represent grants and contracts.

2/ From NIH Data Book (1982-88 editions, and pre-publication data).

3/ From ADAMHA (1978-83, FY 1980-87 editions).

4/ Extracted from annual reports provided by HRSA, Division of Nursing, and NIH Data Book. Authority for nursing research training was transferred from HRSA to NCNR/NIH in 1986. As a result, nursing research and training data are included with other NIH research and training awards beginning in 1986. The 1988 NIH Data Book shows NCNR R&D Grants and R&D Contracts (in millions) of some $20.6 in 1986 and $33.1 in 1987. Training awards (in millions) by NCNR amounted to $1.0 in 1986 and $2.1 in 1987; training expenditures as a percentage of research obligations are, therefore, 4.9% and 6.3% for 1986 and 1987, respectively.

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American Dental Association

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# BIOMEDICAL AND BEHAVIORAL RESEARCH SCIENTISTS: THEIR TRAINING AND SUPPLY

## Volume III: Commissioned Papers

Committee on Biomedical and Behavioral
Research Personnel

Office of Scientific and Engineering Personnel
National Research Council

in collaboration with the
Institute of Medicine

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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# BIOMEDICAL AND BEHAVIORAL RESEARCH SCIENTISTS: THEIR TRAINING AND SUPPLY

## Volume III: Commissioned Papers

# CONTENTS

Evaluating the National Research Service Award Program:
A Review and Recommendations for the Future
by *Georgine M. Pion* 1

Productivity
by *Helen Hofer Gee* 41

Health Services Research Personnel:
Demand, Supply, and Adequacy of Training Programs
by *Elizabeth McGlynn* 75

Training of Physician/Scientists
by *Lloyd H. Smith, Jr.* 107

Biomedical/Behavioral Cohort Model: A Technical Paper
by *Joe G. Baker* 121

# EVALUATING THE NATIONAL RESEARCH SERVICE AWARD PROGRAM: A REVIEW AND RECOMMENDATIONS FOR THE FUTURE

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The focus of this paper is (1) to review previous evaluation activities of the National Research Service Award (NRSA) program and (2) to propose an agenda describing the types of evaluation activities that should be carried out over the next 5 years. In line with this emphasis, a description of the major evaluation questions of interest to key program constituencies will be presented. Then, previous evaluation efforts will be discussed in terms of whether they addressed these questions and provided answers that could be viewed with a reasonable degree of confidence. The "match" between the questions of interest and the availability of sound evidence for answering these questions as gleaned from previous evaluations to date will serve as the basis for recommending future evaluation priorities.

Throughout this paper, two considerations should be kept in mind. One concerns the diversity of the NRSA program itself. At first glance the overarching goal of this program is relatively straightforward: to train individuals for health-related research and teaching careers. However, in achieving this mandate, several different components and activities are encompassed by the program. For example, NRSA awards support training in a heterogeneous group of disciplines, ranging from genetics to health services research, and activities are administered by a variety of federal agencies and institutes, each with varying levels of experience in supporting research training. The training sponsored by these agencies also differs in terms of academic level (undergraduate, predoctoral, or postdoctoral), target populations, e.g., M.D.s, Ph.D.s, or ethnic minorities), and strategies (e.g., short-term training versus formal degree programs or disciplinary versus multidisciplinary approaches). Further, distinct funding mechanisms (individual) fellowships versus institutional training grants) are used to support activities, incorporating different selection procedures and educational strategies (e.g., "one-to-one" individually negotiated, student/mentor apprenticeships versus more formally structured degree programs within an institution). Consequently, previous evaluations in the NRSA program differ in terms of the specific program of interest, the target populations examined, the training activities involved, and the outcomes studied.

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It also must be remembered that the NRSA program is but one benefactor of research training. Both the National Institutes of Health (NIH) and the Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA) sponsor other programs with quite similar aims (i.e., increasing the supply of productive researchers in health-related areas). These programs either directly or indirectly sponsor research training and/or research career development (e.g., Research Career Development Awards, Clinical Investigator Awards, the Minority Biomedical Research Support program, and individual investigator R0-1 grants). In addition, other federal agencies and nonfederal organizations support research training in biomedical and behavioral research at some level (e.g., the National Science Foundation's Graduate Fellowship Program and the Robert Wood Johnson Clinical Scholars Program). Thus, the goals, functioning, outcomes and effects of NRSA programs must be viewed within the larger context of research training occurring in university departments, medical schools, faculty laboratories, and independent research centers.

## WHAT TYPES OF EVALUATION QUESTIONS ARE OF CURRENT INTEREST?

In reviewing the quality of NRSA evaluation efforts, a major issue concerns the extent to which previous evaluations have addressed questions posed by major constituencies. Given that evaluations are intended to provide useful results, studies should speak to the key concerns expressed by the various stakeholders involved with the program.

Four major constituencies for the NRSA program can be identified. They include (1) Congress, which is responsible for authorizing the program and appropriating funds; (2) NIH and ADAMHA, along with their individual institutes, which are in charge of administering the programs; (3) the individual fellows, trainees, and faculty involved in NRSA-supported training activities; and (4) other audiences with vested interests in training researchers (e.g., professional associations, scientific societies, and national "blue ribbon" committees concerned with research and science policy). In order to identify the issues of primary interest to these constituencies, relevant legislation and evaluation reports were reviewed. Individual interviews with congressional staff, federal agency personnel responsible for NRSA policies and evaluation activities, and individuals in charge of specific NRSA programs (N = 16) also yielded insight into the questions for which evaluative data are sought.[2]

It should be noted that neither is interest in these questions always generated independently by each constituency nor is each constituency equal in terms of the urgency with which its demands are accommodated. For example, questions dictated by reauthorizing legislation and formal requests from congressional oversight committees to federal agencies mandate a response; Congress indeed is the holder of the purse strings, and given limited time and resources, its requests often rank higher on the list of agency priorities for evaluation. In addition, the evaluation questions of most interest to a particular group often depend on the extent of its nature with the NRSA program. For example, agency staff whose major responsibility lies in administering institutional training grants may be most enthusiastic about collecting data that could improve their ability to monitor and guide programs; in contrast, scientific societies' demands may stem primarily from their desire to develop stronger arguments for increased NRSA funding in their respective discipline(s).

The major evaluation questions that have been and/or currently are of interest to key NRSA constituencies can be categorized into seven generic types. These include questions about[3]

- the demand for the NRSA program (e.g., the adequacy of the current supply of for biomedical researchers);
- levels of program participation, including numbers and characteristics of awardees;
- characteristics of program operation and functioning, such as whether payback requirements affect the attractiveness of the NRSA program to qualified applicants;
- program outcomes (e.g., the research career accomplishments of awardees) and/or program effectiveness (e.g., whether the subsequent success of awardees in obtaining federal grants is directly attributable to the program);

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[2] A list of individuals interviewed is available from the author upon request.

[3] Because of time constraints, attention was focused on those constituencies most involved in setting priorities and administering policies for NRSA programs (i.e., Congress and federal agencies).

- outcomes and/or effectiveness of individual NRSA components (e.g., whether the Medical Scientist Training Program is more successful in training physician/investigators than extramural postdoctoral traineeships, intramural fellowships, physician/scientist awards, and/or a combination of training support mechanisms);
- cost-effectiveness of the NRSA program; and
- the development and maturation of scientific careers in general and the role of research training in this process (e.g., the components and determinants of scientific productivity).

Appendix A provides detailed examples of the questions that emerged during interviews with congressional staff, federal agency personnel, and others involved in research training activities and policy.

## DEMAND FOR THE PROGRAM AND LEVELS OF PARTICIPATION

Having definitive data on the need for research training support and levels of participation in NRSA programs are "bottom line" demands of all major stakeholders. For example, both the authorizing and reauthorizing legislation for the NRSA (e.g., P.L. 93-348 and P.L. 100-607) specify that awards are to be made only in areas/fields that have demonstrated a need for researchers. As such, Congressional appropriation committees traditionally have sought to base their fiscal decisions on this information, and actual "numerical recommendations" that indicate the number of training slots necessary to address shortages of researchers in specific areas have been frequently requested.[4]

Agency staff share this predilection for reasonably precise estimates of researchers needed in specific fields, disease categories, or problem areas. Other groups, including both those who lobby Congress regularly for NRSA funding in individual disciplines and those concerned with the overall health of the scientific enterprise, also clamor for better projections of supply and demand. Occasionally, these stakeholders have even launched their own data collection efforts in an attempt to obtain this information (e.g., Barries, 1986; Porter, 1979).

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[4] In addition to specifying the number of training slots needed in a field or research area, there was a consensus among congressional staff that better explanations about the ways in which recommendations were derived (e.g., the assumptions underlying supply and demand models) were needed.

Related to supply and demand issues are questions about the "niche" occupied by NRSA programs in the overall landscape of research training support. All constituencies interviewed want to know the types of sponsors, the levels of their investment, and major priority areas for funding. Congress, in particular, wants such descriptive information so as to ascertain what the appropriate role of the federal government should be in the research training enterprise.

A third question of perennial interest, frequently arising at congressional hearings, centers around the distribution of NRSA programs and funds. All constituencies want an accounting of awarded fellowships and traineeships, the research fields supported (e.g., nursing or primary care research), and changes over time. Such data are perceived as crucial to determining whether NRSA expenditures are targeted at "shortage" areas, to ascertaining whether agencies have responded to specific congressional directives, and to identifying where changes in NRSA program priorities or policies may be warranted. Also viewed as important is information on the characteristics of awardees, typically in terms of their sex, race/ethnicity, and institutional affiliation. Many of these questions have been spurred by disappointment in the low rates of participation by women and ethnic minorities in science, coupled with a concern that the nation's pool of scientists and engineers may prove inadequate to meet future challenges (e.g., Office of Technology Assessment, 1985; Vetter, 1989).

## PROGRAM CHARACTERISTICS AND OPERATION

Of primary interest to federal agency staff who administer NRSA programs and policies are questions related to program functioning. These questions are quite diverse in their scope and content. They include requests for information on how institutional review groups (IRGs) make decisions about training grant awards, the amount and types of research training received by predoctoral and postdoctoral trainees, and whether faculty mentors indeed have active research programs in areas most relevant to an institute's goals and objectives.

Program officers, however, are not the only source of these questions. The legislation for the NRSA program itself (e.g., P.L. 100-607) speaks to the general need for program monitoring so as to "determine what modifications in the [NRSA] programs are required to meet the needs [for research personnel]." More explicitly framed "operational" questions also have been posed by Congress, including how the payback requirement and current stipends for NRSA awards affect participation in the program.

## PROGRAM OUTCOMES AND PROGRAM EFFECTIVENESS

Questions related to both absolute outcomes (the accomplishments of NRSA trainees and fellows) and comparative outcomes (e.g., the performance of NRSA-funded predoctoral students in the life sciences as contrasted with those supported by the National Science Foundation) are specified clearly in the legislation. All authorizing and reauthorizing language states that National Academy of Sciences shall "identify the kinds of research positions available to and held by individuals completing [NRSA and other current training programs]" (e.g., P.L. 100-607, Part F, Section 489). Another example appears in the Health Research Extension Act of 1985 (P.L. 99-1258), which requested data on the "number of persons who receive NRSA awards and who engage in health research or training as a career."

On the other hand, questions related to program effectiveness (i.e., whether outcomes are directly attributable to NRSA-supported training) are much less frequent and clearly enunciated. A broad and relatively vague mandate for effectiveness data appears in the law (P.L. 100-607); NAS is directed to "assess [current NRSA programs] and other current training programs available for . . . such personnel." Aside from this fairly global injunction, however, being able to confidently link NRSA training with specific achievements ranks lower on Congress's list of evaluation priorities.

Agency staff members also express less interest in effectiveness questions, particularly if the attention paid to them is at the expense of other data collection efforts. What does generate enthusiasm among this group, is obtaining better information on program outcomes--both in absolute and comparative terms. Training officers at the various institutes want to know what happens to their awardees--for example, whether they remain active in research, whether their research is in the area of their NRSA training, and whether they have been instrumental in training other researchers. If these outcomes ultimately can be contrasted with the performance of individuals who received other types of research training that is supported by either their own agencies or by other sponsors, this would be an additional asset.

It is likely that the lower priority assigned to addressing effectiveness issues stems from an array of factors. For example, there is an awareness of the enormous difficulty and cost involved in obtaining unequivocal data on the effects of research training, given the current structure of these programs (e.g., the heterogeneity of training experiences and the lack of uniformly applied selection criteria). Related to this is the strong sentiment, based on the substantial erosion in NRSA training monies over the last decade, that the first priority for spending any additional funds appropriated by Congress must be to increase the number of training slots rather than to initiate rigorous impact evaluations. Further, in many programs staff members maintain that the necessary data for answering more basic questions about program demand and operation are not available and that this situation must be corrected before such "second-order" questions as program effectiveness are considered.

When questions as to the effectiveness of NRSA programs do surface, they typically center around issues of relative effectiveness. For example, data that can "tease out" the effects of NRSA programs in producing biomedical researchers relative to the performance of other research training programs with similar goals are deemed more salient than evaluations aimed at understanding whether NRSA training is more effective than no research training at all or research training that is entirely financed by the individual through loans or other personal sources.

## OUTCOMES AND/OR EFFECTIVENESS OF INDIVIDUAL PROGRAM COMPONENTS

As previously mentioned, the NRSA comprises a heterogeneous group of programs, many of which also have distinct program components. These include different funding mechanisms, different target populations, and different training philosophies and strategies. Outcomes associated with these individual components and their relative effectiveness have comprised the focus of congressional and administrative inquiries. For example, the Health Research Extension Act of 1985 requested a study on "the effectiveness of [the training grant] mechanism in encouraging individuals to engage in health research and training as a career." Of constant concern to agency staff is "what works best" among or within NRSA components. Illustrative of this interest are such questions as "Are M.D./Ph.D. programs or postdoctoral traineeships more efficacious in producing physician/investigators?" and "Is predoctoral training that is grounded in a particular discipline more successful for increasing the number of researchers attacking alcohol-related health problems than predoctoral training that incorporates several disciplinary perspectives and methodologies?"

### Cost-Effectiveness

For the most part, cost-effectiveness questions do not constitute a high priority among major constituencies. The few questions that emerged in the interviews pertained to identifying ways to "best use the training buck," particularly if research training funds continue to erode. Somewhat related to this concern are more global questions associated with the personal, disciplinary, and social costs incurred from having an insufficient amount of research monies available to support the number of high-quality applications for individual investigator awards from researchers who have been trained in NRSA programs.

### Development and Maturation of Scientific Careers

More frequently, the questions of interest to key NRSA constituencies are those that address research training, scientific productivity, and scientific career development in general rather than with regard to NRSA programs in particular. These questions span a variety of topics, including the relationship between research training and the quality of research, the factors governing an individual's choice to pursue a scientific career, and the resources required to most successfully maintain a productive research career. Also included in this category are those questions posed by agency staff about how to best measure relevant outcomes of research training (e.g., "active involvement in research" and "quality of research"). Although such questions are important for guiding and improving future evaluations of the NRSA program and can indeed be addressed by well-designed studies, it must be kept in mind that providing answers is neither the sole responsibility of NRSA nor the evaluation efforts connected with this program.

### Where Improvements in Evaluation Activities Are Needed?

In the previous section the major evaluation questions of current interest to key constituencies were identified. Although these questions covered all aspects of the program, the priority areas centered around those issues associated with demand for the program, levels of participation, characteristics of training and recipients, and program outcomes.

To date, past evaluation efforts have provided a wealth of data about National Research Service Awards, but many questions basic to understanding how these programs operate and what happens to awardees remain. Most individuals in charge of NRSA programs often continue to find themselves operating in almost a vacuum with regard to having sound, empirical data about how awardees are selected, the characteristics of participants, and the training environments and activities supported. Further, knowledge about the subsequent performance of awardees currently is confined to a limited set of indicators that vary considerably across individual NRSA programs and that incompletely characterize the intended outcomes. Improving this situation (i.e., "filling the gaps") is what must drive the individual items included in any portfolio of future evaluation activities.

Four major gaps exist in terms of having an adequate knowledge base about NRSA programs:

1. Basic questions about program participation and functioning, although of great interest to key constituencies, have remained inadequately addressed.

2. Our understanding of program outcomes, let alone program effects, is still limited.

3. Insufficient attention has been given to determining what works best across and within program components.

4. Evaluation efforts have been sparse in many fields and research problem areas.

The first three gaps focus on "points of slippage" between the types of evaluation questions currently of interest to major constituencies and those that have comprised the thrust of prior evaluation efforts. An examination of the generic questions addressed by the 16 evaluation studies/reports reviewed indicated that 56 percent (N = 9) addressed program participation issues, and 50 percent (N = 8) collected data on program characteristics and operation. The overwhelming majority (94 percent, N = 15) presented information on one or more outcomes for programs or program elements, and 38 percent (N = 6) attempted to address in some way the effectiveness of NRSA programs or distinct components. None of the studies reviewed dealt with issues of cost-effectiveness.[5]

At first glance these percentages suggest that many of the questions of interest to NRSA stakeholders (e.g., program outcomes) indeed have been addressed. However, it must be remembered that within each of these generic evaluation issues lie a variety of subquestions. For example, questions about program operation encompass the nature of the trainee selection process, characteristics of training, and the relationship of the payback requirement to participation levels. As shall be seen, the match between constituency priorities and evaluation efforts on these more specific questions is where the discrepancies surface. (See Appendix A for a detailed enumeration of the questions posed by constituencies and Appendix D for a listing of those addressed by evaluation activities.)

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[5] Given that studies could focus on more than one type of evaluation question, these percentages do not sum to 100 percent. Information on how the evaluations were chosen for review and on the broad categories of questions addressed by each is presented in Appendixes B and C, respectively.

In classifying these evaluations, distinguishing between "outcome" studies and "effectiveness" studies has been in many cases a matter of judgment. For the purposes of this paper, an effectiveness study is one that incorporated either methodological (e.g., matching) and/or statistical procedures so as to control for selectivity bias. Those studies that attempted to compare outcomes but did not include any real consideration of selectivity bias were designated, rightly or wrongly, outcome studies.

## GAPS IN UNDERSTANDING PROGRAM PARTICIPATION AND OPERATION

Although past evaluation efforts have addressed aspects of program participation and operation, several issues have escaped careful examination, including some that are basic to understanding any discrete program or intervention (e.g., program implementation). This situation is partly an outgrowth of the limited amount of resources that have been allotted for evaluation activities. Consequently, some programs (e.g., those sponsored by ADAMHA) have received little scrutiny. Another problem has concerned the fact that when evaluations were initiated, the short timelines imposed often dictated that the focus be on collecting outcome data (no mean feat by itself), with only secondary attention given to examining participation levels or program characteristics. As a result, summary profiles describing NRSA applicants, awardees, and program activities are either nonexistent, sketchy, or idiosyncratic in terms of the populations covered, the variables of interest, and the time periods examined.

### Needed Information on the Demand for the Program

Although development of better supply and demand indicators for biomedical and behavioral science research personnel is covered more thoroughly in the full committee report, one related component deserves special mention in this paper. This concerns the extent of our knowledge about the research training enterprise as a whole (e.g., the total amount of funds, training opportunities, and types of training provided by all sponsors). Congress' motivation for having such information stems from its desire to ascertain what its role should be in financing research training and then to apply this understanding when making decisions about the NRSA program. Similarly, the interest of NIH and ADAMHA staff arises from their wish to better understand their own agency's total involvement in research training, particularly by mechanisms other than those covered under the NRSA umbrella (e.g., research assistantships paid by grants to individual investigators).

Answers to these questions also are requested in the charge for evaluation specified in the authorizing and reauthorizing legislation for the NRSA program: to "assess current [NRSA programs] and other current training programs available for the training of such personnel" (P.L. 100-607, Part F, Section 489). To carry out this charge, a map of the geography and topography of non-NRSA funding sources and mechanisms for research training must be constructed.

Previous committee reports (e.g., National Research Council, 1977, 1981) have attempted to survey this terrain, but this is no easy task. Currently, the best sources of data are the annual Survey of Earned Doctorates (SED) conducted by the National Research Council and the National Science Foundation's (NSF) Survey of Graduate Science Students and Postdoctorals. However, each has certain limitations. For example, the NSF survey requires institutions to indicate only one source of support for a graduate student. Although respondents to the SED are instructed to identify all sources of support and estimate the percentage of support received from each source, their ability to reconstruct these data accurately is unclear.

Understanding the variety of research training activities sponsored by NIH and ADAMHA via non-NRSA mechanisms represents one step toward mapping the terrain, however. Of particular interest here is predoctoral and postdoctoral research training paid by research grants to individual investigators. Available data suggest that the use of this mechanism in supporting research training is not infrequent; research assistantships paid by federal and other grants were a source of predoctoral support for 16 percent of the 1987 Ph.D. recipients in the life sciences--an almost equal percentage to that reported for NIH traineeships (Coyle and Thurgood, 1989).

Developing this capacity to obtain detailed training support data for all Public Health Service agencies may be more feasible than one might expect, given earlier and more recent efforts by NIH and ADAMHA. Information on all paid and unpaid personnel working on research grants was collected on a sample basis for all PHS grants in 1963 and NIH grants in 1969; beginning in 1973, these data were again requested of all NIH grantees in the NIH Research Grants Manpower Survey. Unfortunately, this effort was abolished in 1980 despite a reasonably favorable evaluation (Williams, 1979).

ADAMHA staff members currently are investigating the feasibility of implementing a similar system for their own research grants and have already developed the system specifications, along with conducting some preliminary pilot tests (see Tjioe, 1989, for a description of this system). Variables in this system include name, social security number, role on the grant, type of position, sex, highest degree(s), year of degree, birth date, field (e.g., surgery), and research discipline (e.g., brain damage) for all personnel connected with awards made by ADAMHA institutes. If resources were available to establish and maintain this data base for all PHS awards, questions relating to the various ways in which research training is supported by these agencies, along with differences across fields and levels of training, could be addressed.

Moreover, the ability to address additional questions concerning research training and personnel, including detecting shifts over time, would be enhanced. For example, postdoctoral research associates supported on faculty research grants (R0-1s) could be identified by the data base at the start of their tenure; these individuals (or a sample) then could be surveyed about their training (e.g., the extent of their involvement in relevant activities and the nature of their relationships with advisors and other faculty) so as to determine whether and how these experiences may differ from those received by NRSA-funded individuals. If it is true that students are supported by various types of mechanisms, a more complete picture of each trainee's or fellow's total PHS-supported research training would be obtained. This would work towards acquiring a better sense of an individual's training support history and help improve efforts to elucidate the relationship of outcomes to types and length of research training.

### Needed Information on Participation Levels and Participant Characteristics

Data relevant to questions asking for the numbers of awardees or positions are readily available. They are published annually in data books or other reports issued by NIH (1987, 1988) and ADAMHA (1989a), along with their individual institutes. They also appear in the majority of evaluation studies reviewed, along with each of the committee's previous reports (e.g., National Research Council, 1983, 1985). Depending on the specific report, information on the number of awardees may be disaggregated by type of training mechanism (individual fellowship versus traineeship), level of training (e.g., predoctoral versus postdoctoral), type of training (e.g., M.D. or Ph.D.), major field grouping, sponsoring institute (e.g., National Cancer Institute), or some combination of these variables.

Detailed profiles depicting even basic demographic characteristics of participants (e.g., sex, race/ethnicity, and educational background), however, are less frequently found in formal evaluation reports, although there are some exceptions. A few evaluation studies (i.e., Coggeshall and Brown, 1984; Garrison and Brown, 1986; National Institute of Dental Research Ad Hoc Consultant Panel, 1988; Velletri et al., 1985) did report descriptive data on awardees' educational backgrounds. Information on sex of awardees was included in Garrison and Brown's (1986) study of NIH postdoctoral appointments. Data on race/ethnicity typically have appeared only in internal program reports or evaluations of the Minority Access to Research Careers

(MARC) programs Garrison and Brown 1985; Primos, 1989a, b; Sherman, 1983b; Task Force on Minority Research Training, 1986).

Developing detailed profiles or time series of participation levels by one or more of these major indices from these documents also is not easy. In part, this is because there exists no agreed-upon format for how to best report these data. It is not uncommon for individual evaluation studies and agency publications to use slightly different lexicons for classifying research fields and specialties, to apply different schemes for aggregating individual disciplines into major field clusters, or to employ different counting strategies (e.g., number of individuals versus full-time equivalents). For example, in some instances MARC awards have been included under predoctoral awards, and in other documents they have been demarcated; sometimes awards made by the Fogarty Center have been included in the total counts (National Research Council, 1979), and sometimes they have not (National Institutes of Health, 1987). Similarly, in 1981 ADAMHA began using a different system for classifying the major fields of their trainees and fellows. Such discrepancies often may be difficult to detect, even for the most savvy user, because of the variability across studies in the use of detailed footnotes.

A more central problem lies in the fact that the accuracy of the information for some demographic variables in the major research training data bases is questionable. Look (1989) identified problems in the IMPAC data file maintained by NIH (the master data base from which the Trainee-Fellow File [TFF] is constructed); these included nonreporting and incorrect reporting of gender and race/ethnicity, along with inconsistent reporting of data on discipline, field, and specialty. It is the case that demographic data are available from other sources, which might then be used to augment gaps in existing agency files. For example, for some programs, particularly small programs such as those administered by the Minority Resources Branch at the National Institute of Mental Health (NIMH), demographic data on trainees and fellows funded by the MARC program are collected and maintained by program personnel (e.g., Primos, 1989a). Information on all Ph.D.s awarded by U.S. universities, which includes those who received NRSA support, also is collected by the SED. However, gaining access to and merging these files with PHS data require resources, and monies typically become available only when large-scale evaluation studies, which focus on outcomes, are commissioned. In addition, information on non-Ph.D. populations (e.g., M.D.s) has proved more difficult to obtain (see Carter, Robyn, and Singer, 1983, and Martin, 1986, for examples of problems with specific data bases).

In general, there remains a paucity of complete and accurate information available on the characteristics of NRSA participants. Although special analyses can be performed and some descriptive data can be "patched together" from previous evaluation studies, many audiences do not know answers to such simple questions as "What have been the trends in NRSA awards in the clinical sciences?" and "What percentages of women and ethnic minorities have received NRSA support?"

This same situation is even more characteristic of applicants to NRSA programs, although the issue is somewhat more complicated. "Applicants" include individuals who apply for NRSA fellowships and institutions that apply for NRSA training grants. Some information is available on the numbers and characteristics of individual applicants for fellowships, and although fellowships do not constitute the bulk of training slots funded, their numbers are not insubstantial (147 fellowships for NIMH in 1987 and 1,664 for NIH in 1986). However, individual applicants who might apply for training grant slots cannot be identified. These persons are selected by training grant directors/committees at individual institutions, and information is seldom reported on unsuccessful candidates, assuming that at least in some cases individuals do apply and some type of selection process occurs (most likely for postdoctoral traineeships). The selection processes inherent in the training grant mechanism thus make a comprehensive profile of all applicants unworkable without primary data collection efforts such as those initiated by Bickel et al. (1981) for the MST program. At the same time, determining whether the award selection process is working as intended and ultimately the effects of the training grant mechanism require that attention be paid to gathering applicant data. In addition, the characteristics of the institutions that apply for training grants are worthy of examination in terms of understanding the geographical distribution of applicants and awards, the factors correlated with awarding funds to a grant application, and so forth.

Increased attention to collecting data on participation issues would contribute to laying a firmer groundwork for understanding not only the demand for the program but also issues associated with how individual or program characteristics may be related to certain successful outcomes. For example, relationships have been found between sex and grant activity for postdoctoral fellows (e.g., Garrison and Brown, 1986) and NSF predoctoral fellows (Snyder, 1988) and between certain characteristics of training programs and subsequent grant application efforts of trainees (C. Roth, personal communication, June 1989).

## Needed Information on Program Characteristics and Activities

There exists a plethora of questions about the characteristics of NRSA programs and their functioning (see Appendix A). These questions not only include ones raised by Congress, which typically focus on program procedures and regulations (e.g., the payback requirement), but also those generated by agency staff (e.g., the nature of the trainee selection process and the types of training activities carried out in funded programs).

About half (56 percent) of the 16 evaluation studies reviewed devoted some attention to program "operational" issues (see Appendix C). For example, descriptive statistics on the duration of NRSA support were contained in evaluations of NIH predoctoral appointments (Coggeshall and Brown, 1984; National Research Council, 1976; Velletri et al., 1985), NIH postdoctoral appointments (Garrison and Brown, 1986), and the National Institute of Drug Abuse and NIDR trainees and fellows (Clouet, 1986; NIDR Ad Hoc Consultant Panel, 1988). Related to this is the need for data describing the extent to which individual awardees receive multiple NRSA awards (e.g., predoctoral and postdoctoral). This aspect has been addressed in a few studies (e.g., ADAMHA, 1986, unpublished report; Coggeshall and Brown, 1984; Garrison and Brown, 1986). Such data are important in order to obtain a good sense of the "dosage" of training and how it might subsequently relate to measures of outcomes and effectiveness.

Other aspects of program operation also have received some scrutiny. In response to a specific congressional request, the influence of the payback requirement on the number and quality of applicants and the number of awardees who pursued health research or training careers was examined by NIH (1986). An in-depth exploration of NIH program "processes" was undertaken by the National Research Council (1978), with site visits to institutions with training grants conducted to obtain a better sense of how training monies were used and to suggest ways in which training policies might be improved. Garrison and Brown (1985), in their evaluation of MARC undergraduate training grants, also obtained qualitative information gleaned from site visits on such operational issues as the activities on which MARC funds were spent, departmental composition, and recruitment practices.

At the same time, a profile of how programs function in terms of recruitment, selection, and actual training activities--issues currently of interest to major constituencies--is not available for the majority of NRSA programs. The lack of these data is disturbing, not only because program modifications may then fall prey to being guided more by personal judgment and experience than by empirical data but also because the success of other evaluation efforts (i.e., outcome and effectiveness studies) hinges on understanding how participants are selected and the distinct types of training (if any) they receive.

Take, for example, the question about how trainees are assigned to training grants, particularly in terms of Ph.D.

predoctoral training and M.D. postdoctoral training. It has been speculated that NRSA support is simply viewed by departments as another "pot of money" that can be channeled to students who currently are not receiving other types of financial aid. If this practice is common, it may mean that traineeships, rather than being highly competitive, are reserved for those individuals judged as less qualified to compete for other sources of support (e.g., prestigious university fellowships or postdoctoral appointments). The situation is further compounded if NRSA stipends are lower than those offered by most other sponsors or if payback obligations are viewed as burdensome by the individuals who would be most qualified to receive NRSA support.

## GAPS IN UNDERSTANDING PROGRAM OUTCOMES AND EFFECTS

Questions concerned with program outcomes clearly are specified in the legislative authority for the NRSA program, along with being of significant interest to agency staff in charge of these training programs (see Appendix A). Here the focus is on knowing what happens to awardees (e.g., "Are they engaged in health research careers?"). As previously discussed, questions concerning program effectiveness also are implied in the legislative authority for the NRSA program and, although not the highest priority, do generate some enthusiasm among some agency personnel.

The questions on effectiveness generating the most interest, however, are not those of the breed "Are NRSA-supported predoctoral fellows more likely to be successful health researchers than those who receive no predoctoral training and/or support?" Rather, they address the issue of relative effectiveness. For example, congressional policymakers want to know if NRSA programs are more effective than research training programs administered by NSF. Agency staff want answers to such questions as "Is predoctoral or postdoctoral training more effective in producing researchers in the clinical sciences?"

Given the strong interest in outcomes, examining program achievements comprised a major emphasis in the overwhelming majority of evaluation studies reviewed (see Appendix C). For the most part, the unit of analysis for these studies was the individual awardee. The role of NRSA training support and the consequences of losing this support on departments were, however, explored in two of these efforts (National Research Council, 1978, 1981).

The bulk of studies focused on those outcomes that to varying degrees reflect involvement in research, given the legislative authority for the NRSA. There was some heterogeneity in terms of the number of outcomes examined, with a few studies

(ADAMHA, 1986, unpublished report; Schneider, 1980) providing data on essentially only one outcome (success in obtaining NIH/ADAMHA funding or type of employer). Across the various reports, there also was considerable variability in which outcomes were examined, depending on the training sponsor (e.g., NIH or ADAMHA), degree and field of training (e.g., Ph.D. or M.D. and biomedical or behavioral sciences), levels of training (e.g., predoctoral versus postdoctoral), and time periods examined.

For any given outcome, however, there was considerably less variation in terms of how it was measured. Awardee outcomes typically were operationalized as attainment of doctorate and pursuit of postdoctoral research training (for predoctoral award recipients); type of employment, usually academic employment; time spent in research; pursuit of and success in obtaining external research grants, particularly grants awarded by NIH and ADAMHA; and publication performance (numbers of publications and citations).

One primary reason for this is that only 4 of the 12 studies involved any primary data collection on awardees; Clouet (1986), the National Research Council (1977), and Sherman et al. (1981) all collected at least some data directly from awardees, and Bickel et al. (1981) surveyed medical school deans about students in their programs. Instead, the typical study has relied on archival data: data on demographic characteristics, educational history, and employment plans of individuals who have just earned their Ph.D. (the Doctorate Records File compiled from the SED); data containing information on all individuals who have applied and/or been awarded grants from PHS agencies (the Consolidated Grants Application File, along with similar data, where available, from such other funding sponsors as NSF); data from a biennial sample survey conducted by NSF on the employment activities of Ph.D.-holders in science and engineering fields (the Survey of Doctorate Recipients [SDR]); and employment data from reports submitted by awardees after completion of their NRSA appointments in order to fulfill payback requirements. This reliance on archival data has at least partly resulted from the constraints imposed by limited funding for evaluation, short timelines for reporting, and OMB regulations for data collection efforts contracted by federal agencies.

In addition to gathering information on outcomes for NRSA recipients, four studies (Coggeshall and Brown, 1984; Garrison and Brown, 1986; NIH, 1986; National Research Council, 1976) did address program effectiveness at some level. These studies were all efforts sponsored by the committee, and for the most part, the major focus was on evaluating NIH programs.[6]

Given that NRSA supports both predoctoral and postdoctoral training for M.D.s and Ph.D.s and that the training strategies for each of these groups are reasonably distinctive, evaluation activities will be discussed separately.

### Predoctoral Training for Ph.D.s.

Three major studies examined outcomes associated with NRSA-sponsored predoctoral training (Coggeshall and Brown, 1984; National Research Council, 1976, 1977). In general, the results indicated that NIH awardees distinctly outperformed their comparisons in terms of greater involvement in research (e.g., receipt of additional postdoctoral research training, time spent in research, and grant application/award activity). These individuals also had somewhat better track records in carrying out high quality research (as measured by citations). Similar to the results of previous studies on the determinants of academic careers (Long, et al., 1979; McGinnis and Long, 1988), awardees did not experience any greater success in locating academic employment, once prestige of doctoral institution had been controlled. For each of these findings, however, the causal linkages between NRSA-funded training and these outcomes remain unclear.

For example, in its survey of 1971-1975 Ph.D. recipients in the biomedical and behavioral sciences, along with nurses who had earned their doctorates during the same time period, the National Research Council (1977) found distinct differences between those individuals who had received NRSA predoctoral support from ADAMHA/NIH/HRA (Group 1) and those who did not receive this support (Group 2). The size of these discrepancies, however, varied across the three broad fields. Looking at individuals' reported success in obtaining PHS support for their current research, the proportions of NRSA awardees versus those who received no NRSA support were 58.5 percent versus 43.4 percent in the biomedical sciences, 29.5 percent versus 16.0 percent in the behavioral sciences, and 38.1 percent versus 18.4 percent for nurses. NRSA awardees in all three fields also were slightly more likely to report greater time spent in research, although the differences were quite small; the average time reported was 59.8 percent for Group 1 members versus 52.0 percent for Group 2 members in the biomedical sciences, with corresponding percentages of 28.4 percent versus 22.6 percent for behavioral scientists and 15.5 percent versus 11.6 percent for nurse-researchers. Awardees in the biomedical sciences also were much more likely to have spent the first year after their doctorate in postdoctoral study (65.2 percent versus 47.9 percent) in contrast to behavioral science Ph.D.s (15.6 percent versus 10.4 percent). Comparisons of the percentages employed in academic environments for each group yielded little or no differences.

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[6] None of these studies had designs that could confidently support causal attributions, however. The majority did use multiple comparisons that embodied differing levels of selectivity, but in some cases, comparisons (e.g., predoctoral awardees versus those with no Ph.D. training) were so hopelessly confounded as to be meaningless. Those that paid some attention to issues of selectivity are the ones that are considered in this paper.

Even with this more narrow focus, summarizing the results of this smaller set of studies is difficult, given the diversity of programs examined, the variability in career patterns and research activities in different fields and specialties, and the influence that differing time periods of training may have on outcomes (e.g., the effect of labor market expansion and contraction on the availability of academic positions).

Better performance in research as a function of NRSA predoctoral support may, however, be simply a product of preexisting differences between the groups and differential training experiences. The groups examined in this study were those with NRSA support and those without NRSA support. This latter group is quite heterogeneous, comprised of individuals who received other types of federal support, university support, or no financial support for their graduate training. Further, the fact that a variety of predoctoral training experiences characterized this group, some that may or may not be similar to NRSA-supported training activities, makes interpretation of both the differences and the lack of differences between these two groups impossible.

Significantly better information is available from two studies that used comparison groups designed to help control for differences associated with heterogeneity of training experiences and, to a lesser degree, selectivity. The National Research Council (1976) compared the types of employment (e.g., academic and business) and time spent in various activities from 1968 to 1970 for three groups of Ph.D.s: (1) awardees of NIH predoctoral support; (2) those who received other non-NIH predoctoral support that could be identified (e.g., awards from NSF); and (3) those who received neither predoctoral support from NIH nor the other agencies covered in the study. In addition, the attempt was made to include only those individuals who had not engaged in postdoctoral study so as to reduce the possible influence of additional formal research training. Similar results were found. Looking at Groups (1) and (2), although the percentage employed in academic environments was almost identical (71.4 percent versus 71.6 percent, respectively), NIH awardees spent more time in research than those Ph.D.s supported by other sources (an average of 53 percent versus 41 percent).

A more recent study (Coggeshall and Brown, 1984) of NIH predoctoral awards also attempted to at least partially control for the heterogeneity of training experiences and selectivity. Looking at those individuals who received their Ph.D.s in the biomedical sciences between 1967 and 1981, three study groups were compared: (1) those who received at least 9 months of NIH predoctoral support; (2) those who earned their degree from the same departments as the first group but who received 0-8 months of NIH support; and (3) those who graduated from departments that did not have NIH training funds. This strategy permitted two important considerations: (1) those departments receiving NIH funds, often the top-ranked departments in the biomedical sciences, apply the same criteria to accept students, and thus those students enrolled in the doctoral program, regardless of their source of predoctoral support, may be more similar in terms of individual differences (e.g., abilities); and (2) that students who are in departments with NIH funded programs but who are not supported by these funds for an extended length of time may benefit from certain resources accruing to NIH-supported departments.

The most instructive comparison in this study for questions pertaining to specific outcomes associated with NRSA support is between those groups from the same set of departments. The findings of previous studies were confirmed. Although there emerged no differences in terms of subsequent academic employment between those with or without NIH support, distinctions did appear in variables related to research performance. For example, the percentage of NIH awardees who subsequently received NIH postdoctoral support was 34.4 percent as compared to only 20.7 percent of their departmental counterparts. Recipients of NIH training funds also were 32 percent more likely to apply for NIH research grants (30.5 percent versus 23.1 percent) and, if they applied, 13 percent as likely to be awarded them (62.3 percent versus 55.0 percent). In general, there was a stronger tendency for NIH awardees to have published at least one article (e.g., 86.3 percent of NIH-supported individuals versus 63.2 percent of those not receiving support for FY 1977 Ph.D.s) and to have more citations per article (e.g., 8.2 versus 6.0 for this same cohort). By examining data on length of NIH predoctoral support, Coggeshall and Brown provided additional insight into NRSA awards, indicating a clear relationship between length of NIH support and performance on several major outcomes.

While such results do suggest that NIH predoctoral support, at least in the biomedical sciences, increases the probability that an individual will have a research career in health-related areas, it nonetheless remains a small role. Analyses regressing years since Ph.D., the quality of the predoctoral institution, and total months of NIH predoctoral support on number of NIH research grant applications, average priority score awarded to

NIH grant applications, total number of articles published, and average number of citations per article published yielded $R^2$s of .08, .06, .06, and .07, respectively (Coggeshall and Brown, 1984). Thus, it is apparent that other factors (e.g., individual abilities, the nature of research in certain fields, subsequent postdoctoral research training, and available resources for research at the awardee's employment setting) remain plausible and key contributors to producing active researchers in these areas.

**Postdoctoral Research Training for Ph.D.s.**

Three major studies have focused on identifying the outcomes of NRSA-supported postdoctoral training, primarily those of biomedical scientists. In general, those with postdoctoral training, regardless of the sponsor, outperformed on all measures as compared to those who were supported for their predoctoral education but who did not choose to pursue additional postdoctoral study.

More recent examinations of NIH postdoctoral training in the biomedical sciences have been carried out for 1964-1977 Ph.D. recipients (National Institutes of Health, 1986) and for 1961, 1966, 1971, and 1976 Ph.D. recipients in the biomedical sciences (Garrison and Brown, 1986). Here the major comparison groups were (1) NIH postdoctoral trainees and fellows, (2) Ph.D.s who had likely received postdoctoral training from other sponsors, and (3) those who reported no plans for postdoctoral study at the time they received their degree. Substantial differences emerged between NIH postdoctoral awardees and those who indicated no plans for postdoctoral study; for example, Garrison and Brown (1986) found that NIH awardees were three times as likely as the "no plans" group to have applied for NIH/ADAMHA research grants (56.9 percent versus 19.6 percent) and four times as likely to have been awarded a grant (40.0 percent versus 9.2 percent). This latter difference was reduced somewhat when only those who applied for grants were considered (70.3 percent of NIH awardees versus 47.1 percent of "no plans" group). They also were more likely than those with no postdoctoral training to have obtained faculty appointments 8-9 years after their Ph.D. (66.7 percent versus 52.7 percent) and, depending on the specific cohort examined, to have published more articles and received more citations per article. A study by NIH (1986) revealed similar findings in terms of academic employment and research funding activity.

Given that individuals who choose to undergo the additional years of training involved in postdoctoral appointments may share certain characteristics that are distinct from those of individuals who do not engage in postdoctoral study, comparing outcomes of NIH postdoctoral awardees with those who had their postdoctoral training sponsored by other agencies is more appropriate for addressing questions related to the specific value of NRSA support. In the studies previously described, the advantages of NIH support remained, although the differences between the two groups were smaller. Comparing Ph.D.s with NIH postdoctoral appointments to those who had their postdoctoral study supported by another sponsor, the National Research Council (1976) found that the NIH study group spent substantially more time in research (an average of 61.2 percent) as compared to those with non-NIH appointments (40.0 percent) and published articles that were more frequently cited by their colleagues (e.g., 73.1 citations per person versus 62.0 for those investigators aged 31-40). In contrast, although both groups had high rates of academic employment, the non-NIH supported postdoctorates were somewhat more likely to be in universities and medical schools (90.5 percent versus 82.2 percent).

As Garrison and Brown (1986) found, NIH awardees continued to outperform in terms of grant application activity those individuals whose postdoctoral training was supported via another source (56.9 percent versus 34.5 percent); Also, they were more likely to have been awarded a grant (40.0 percent versus 22.3 percent); this disparity decreased substantially, however, when considering only those applying for such grants (70.3 percent versus 64.8 percent). There did appear to be some advantage in terms of academic employment; the percentage obtaining a faculty position was 66.7 percent for NIH awardees as compared to 56.7 percent for those with other types of postdoctoral training, but consonant with previous research (McGinnis, Allison, & Long, 1982), this relationship could be primarily accounted for by other factors (e.g., prestige of doctoral institution). Similar results were reported by NIH (1986).

Similar to the situation that exists for predoctoral training, however, multiple regressions on such outcome measures as grantsmanship that controlled for other factors (e.g., selectivity of baccalaureate institution and reputation of doctoral institution) yielded small multiple $R^2$s, ranging for the most part from .06 to .14 (Garrison and Brown, 1986). This reinforces the conclusion that several other factors contribute to fostering successful research career paths and achievements, although little is known about the exact nature and strength of the relationships.

### Postdoctoral Training for M.D.s.

The role of postdoctoral training for M.D.s was examined by the three studies discussed in the preceding paragraphs. However, the difficulty in interpreting the results--resulting from problems encountered in drawing comparison groups resembling in both orientations and experiences M.D.s with NRSA-supported, postdoctoral research training--is exacerbated, given that the vast majority of physicians do not follow research careers. In addition, identifying reasonable comparison groups in these retrospective studies is further complicated by the fact that existing data bases for physicians typically are less complete that those for Ph.D. recipients.

Differences between M.D.s with postdoctoral appointments and those without postdoctoral training, some of which appear to be substantial, were found by the National Research Council (1976) for certain outcomes: employment in medical schools and universities (40.9 percent versus 7.4 percent, respectively); the average amount of time reported in conducting research (10.6 percent versus 2.6 percent); and numbers of publications and citations (e.g., 58.6 citations versus 10.3 citations per person for M.D.s aged 41-50). By the use of additional comparison groups, a strong relationship between the existence and length of formal research training and outcomes also appeared--a relationship that has been supported by analyses of more recent trainees (Levey et al., 1988; Sherman, 1983a, 1983b, 1989). In addition to the M.D. groups specified above, two other groups were identified: individuals who had earned both an M.D. and a Ph.D. and who had or had not received postdoctoral training. With the exception of average time spent in research, the results showed a ranking among these groups in line with the amount of research training received. For example, the proportions employed in academic settings were 67.5 percent for M.D./Ph.D.s with postdoctoral appointments, 60.4 percent for M.D./Ph.D.s who did not pursue postdoctoral study, 40.9 percent for M.D.s who had NIH-supported postdoctoral appointments, and 7.4 percent for M.D.s with neither a Ph.D. nor postdoctoral training. On each of the four measures used in the study, the performance of M.D./Ph.D.s, regardless of whether they had been engaged in postdoctoral study, was higher than for those M.D.s who did not possess a Ph.D.

The two remaining studies tried to draw comparison groups that addressed in some way selectivity issues. Rather than looking only at all M.D.s without postdoctoral training, Garrison and Brown (1986) also identified another group of M.D.s who received their degree in 1965 or 1974, who reported their primary activities to be "research" or "teaching," but who had not received postdoctoral research training. Looking at 1974 M.D.s only, there were differences between this group and NIH postdoctoral trainees and fellows. For example, those M.D.s with NIH-supported postdoctoral training also were slightly more apt to have applied for NIH/ADAMHA research grants (18.6 percent versus 12.0 percent) and subsequently been awarded funding (8.7 percent versus 5.5 percent).

A comparison of these outcomes between M.D.s who had NIH postdoctoral fellowships and those who had unsuccessfully applied for these fellowship was performed by the NIH (1986). Although both this study and the Garrison and Brown (1986) study demonstrated that NIH fellows comprise a small and select group of M.D.s with NIH postdoctoral awards, this comparison is instructive, although still equivocal, in that it attempts to address some issues of selectivity. Looking at 1968 and 1971 M.D. recipients, the National Institutes of Health found the NIH fellows consistently outperformed their unsuccessful applicant counterparts in terms of medical school faculty appointments (65.1 percent versus 43.5 percent) and NIH/ADAMHA application activity (27.4 percent versus 19.4 percent). Of those who applied for grants, 59.1 percent of the fellows versus 33.3 percent of the unsuccessful fellow applicants received an award.

In general, all of the previously described studies on predoctoral and postdoctoral training have contributed to our knowledge about certain accomplishments of NRSA awardees. Because of unresolved problems with selectivity and heterogeneity of training experiences, however, they have yet to yield strong evidence concerning the effects of NRSA training.

## GAPS IN UNDERSTANDING OUTCOMES AND EFFECTS OF NRSA PROGRAM COMPONENTS

The NRSA program is comprised of several different programs and/or components. For example, there are two basic award mechanisms--individual fellowships and departmental training grants. These mechanisms can be regarded as distinct components, given that they involve different selection procedures and possibly different training experiences. Evaluation studies have paid attention to identifying outcomes and, occasionally, effects associated with these two funding mechanisms, along with examining similar questions for other types of programs/components.

Differences in the outcomes for trainees versus fellows have been investigated by several efforts (ADAMHA, 1986, unpublished report; Clouet, 1986; Coggeshall and Brown, 1984; Garrison and Brown, 1986; NIDR Ad Hoc Consultant Panel, 1988; NIH, 1986; Velletri et al., 1985). For the most part, each has shown that fellows consistently outperformed their trainee counterparts on all measures of interest.

Garrison and Brown (1986) looked at several distinct programmatic strategies aimed at providing M.D.s with postdoctoral research training. These included training appointments for study at NIH and extramural awards (individual fellowships and training grants). Five groups were examined: (1) M.D.s who had extramural fellowships and NIH intramural appointments; (2) M.D.s who had extramural traineeships and NIH intramural appointments; (3) those who only had received NIH intramural appointments; (4) M.D.s who only received extramural fellowships; and (5) M.D.s who only received extramural traineeships. In general, the results indicated that individuals with appointments stemming from very competitive selection procedures (extramural fellowships and intramural appointees) were more likely to receive research support from NIH or other major biomedical research sponsors, to have academic appointments, and to exhibit better publication records. Those with both forms of training had the highest performance on every outcome measure.

Other distinct NRSA program components also have been evaluated. One program involves the institutional training grants supported by MARC (Honors Undergraduate Research Training Grants). Garrison and Brown (1985) conducted a study of those programs that were sponsored by NIH, gathering data on how the program was functioning, the outcomes of program graduates, and the impact on the institution. For example, they examined the types of activities supported by these programs, student satisfaction with the program, educational and occupational status of former program alumni, and institutional enrollments of ethnic minorities in the biomedical sciences. From these data, they found general satisfaction with the program, a substantial proportion of program alumni currently enrolled in another graduate or professional program, and a higher percentage of biology baccalaureates awarded by institutions that had MARC programs as compared to those with no MARC program. Limited outcome data on MARC awardees supported by ADAMHA also have been collected, with the most recent results indicating that 75 percent of students supported during the 1980-1986 period were enrolled in graduate school, along with another 4 percent in medical school (Primos, 1989a).

Another component--short-term research training in health profession schools that received support from NIH--was examined by Sherman (1984). This study involved two components: (1) an examination of whether short-term trainees who had been enrolled in the program during the 1961-1970 period had applied for and/or received NIH/ADAMHA research grants and (2) a comparison of career and research plans and preferences of 1982 and 1983 medical school graduates who had received short-term training and who had not. Although the data suggested a stronger research commitment among program participants as compared to those graduates who were not enrolled in this program, selectivity problems make interpretation of these results impossible.

One distinct and highly visible component is the Medical Scientist Training Program (MSTP). Only two small-scale studies of this program have been conducted aimed at training physician/scientists. Bickel et al. (1981) surveyed medical school deans to examine the adequacy of the number of MSTP training slots, given the pool of qualified applicants, and to compare attrition rates for students in MSTP with those for other M.D./Ph.D. programs. A second study by Sherman et al. (1981)

attempted to assess the effectiveness of MSTP in producing physician/scientists, along with other M.D. research training programs (NIH-supported postdoctoral fellowships and traineeships, NIH research associateships, and NIH clinical associateships). Individuals graduating from MSTP between 1968 and 1973 were matched with students who subsequently trained in one of the other three programs and who were similar in certain characteristics (e.g., type of medical school, age, and MCAT scores). The results suggested that MSTP graduates outperformed the other groups in terms of achieving faculty status and advancement, obtaining NIH research grants, and publication performance.

Since that time, evaluation activities of the MSTP have been minimal (i.e., a brief telephone survey of graduates by program staff and procuring additional analyses of the data collected in Coggeshall and Brown's 1984 study of NIH predoctoral trainees and fellows). To date, there are no firm plans for a more comprehensive evaluation, although the committee in 1983 recommended that a better "picture of costs, training completion rates, post-training employment histories, scientific accomplishments, etc." be developed (National Research Council, 1983).

## GAPS IN BASIC EVALUATIVE DATA FOR PROGRAMS IN SPECIFIC FIELDS/RESEARCH PROBLEMS

The large majority of evaluation studies have focused on NRSA programs administered by NIH. In contrast, evaluation of NRSA-supported training at ADAMHA are both few in number and restricted in scope and coverage. Of the three efforts reviewed, only one included all ADAMHA awardees, another focused on individuals supported by a single institute (NIDA), and the third examined one specific program within an institute (psychology research training sponsored by NIMH). To date, the primary source of evaluative information about programs in health services research (now residing in NCHSR) and those in nursing, administered by the Center for Nursing Research resides in the Committee's report issued in the late 1970s (National Research Council, 1977).

Even when evaluations of ADAMHA programs were carried out, these efforts were circumscribed in nature. Activities typically focused on only a small set of outcomes (e.g., success at obtaining PHS research grants or initial employment of predoctoral trainees after receipt of the doctorate). No attempts were made at examining program effectiveness.

This situation is in some ways not surprising. Since 1975, the bulk of training has been supported by NIH; about 9 of every 10 fellowships and training grants have been awarded by NIH programs (Biomedical and Behavioral Research Personnel Committee, 1989). At the same time, however, this skewed distribution of evaluation efforts has resulted in a lack of information about research training in many fields/research areas, given that ADAMHA, NCHSR, and the Center for Nursing Research provide much of the federal research training support in the behavioral sciences, health services, and nursing.

## RECOMMENDATIONS FOR FUTURE EVALUATION ACTIVITIES

The major "gaps" described above imply that any portfolio of future evaluation efforts for the NRSA program should consider the following issues:

- The quality of the major data bases on NRSA appointments should be assessed so as to ensure that information on program recipients covers the key characteristics of most interest, is accurate, and is collected uniformly on all NRSA components.
- A core set of evaluative data to be collected for all research training programs funded by NRSA should be identified.
- Future efforts should be targeted at gathering information on program characteristics and operation, including data on selection of fellows and trainees, the types of training activities received by individuals in the program, and how these may differ across various program components, fields, and so on.
- Increased attention should be paid to measuring the full range of program outcomes both in absolute and comparative terms.
- In order to facilitate the development of outcome assessments, basic research on scientific career development and maturation, scientific productivity, and the dynamics of training should be supported.
- Although interest in determining the effectiveness of NRSA programs is relatively circumscribed and many aspects of the program currently are not amenable to rigorous impact assessments, the feasibility of implementing effectiveness studies, at least for distinct components of the program, should be explored.

## ENSURING THE QUALITY OF DATA BASES ON NRSA APPOINTMENTS

The Trainee-Fellow File (TFF), derived from the IMPAC file on all extramural awards made by PHS for research, training, and other activities, is the primary source of information on all persons applying for and receiving fellowships and/or traineeships from NIH, ADAMHA, and other PHS agencies. Thus, having accurate and up-to-date information is extremely important for identifying the populations and subgroups eligible for inclusion in evaluations of the NRSA program. In addition, the ability to use archival data successfully from other major data bases (e.g., the SED and the Consolidated Grants Application File) to augment the TFF would be enhanced.

Clouet's (1986) study of NRSA trainees and fellows supported by the National Institute of Drug Abuse identified misclassification problems in the TFF, at least for NIDA awardees. In the course of identifying NIDA grantees listed in this data base, she found that 67 percent of the student awards identified from agency files were not in the TFF and that over 1,000 people in NIDA nonacademic training programs were included. The extent to which these problems apply to data for other institutes administering NRSA programs is unclear, although interviews with NIH officials did not suggest that it was symptomatic of NIH programs. At the same time, however, Look's 1989 examination of the information available on trainees and fellows suggests that other problems (e.g., inconsistent and even inaccurate reporting on basic demographic characteristics) may exist. Thus, attention should be paid to assessing the quality of data in the TFF and resolving any problems, particularly in light of the following recommendations aimed at increasing evaluation efforts of NRSA programs.

## ENSURING A CORE SET OF EVALUATION ACTIVITIES FOR ALL NRSA PROGRAMS

To date, evaluation activities for programs in certain fields or areas (e.g., the behavioral sciences and health services research) have been minimal and haphazard. For this reason there are no bodies of information for these fields comparable to that existing for the biomedical and clinical sciences. For example, the primary source of outcome data on health services research training support is the National Research Council's 1977 survey. In the case of the behavioral sciences, similar data were collected in the National Research Council's 1977 study, and although other evaluations did include the behavioral sciences in their populations, they were less than illuminating--either because the studies did not analyze the results for the behavioral sciences separately (e.g., Coggeshall and Brown, 1984) or because the measurement of outcomes was restricted to a single variable, with no incorporation of reasonable comparison groups (ADAMHA, 1986, unpublished report; Schneider, 1980).

This distinct gap in our understanding of the role played by NRSA-supported training for major broad fields of biomedical and behavioral research should be remedied. As found in previous studies of research training, distinct differences in patterns of study and accomplishments appear with respect to individual fields (National Research Council, 1981b; Snyder, 1988). Further, those fields that are most lacking in evaluative data are those that also make substantial contributions to addressing key health and mental health problems (e.g., National Research Council, 1985), along with other social concerns (e.g., Gerstein et al., 1988).

Moreover, there is some suggestion that there may be future shortages of qualified researchers in these areas. A recent analysis by ADAMHA (1989b) indicated that the pool of researchers working in alcohol abuse, drug abuse, and mental health areas is aging rapidly; in 1979, 26 percent of ADAMHA-funded investigators were 35 or younger, and this percentage has declined to 13 percent in 1987. The proportion of young applicants to ADAMHA has followed a parallel trend. In addition, the average age of Ph.D. principal investigators has increased 1.6 times faster than the average age of NIH-funded researchers.

The key point is that there should be a core set of evaluative data collected on all NRSA programs and research areas. Only in this manner can the scope and breadth of NRSA activities be examined and strategies developed to improve programs aimed at all fields, levels, and types of research training supported by NRSA funds.

## INITIATING EVALUATION ACTIVITIES THAT PROVIDE BETTER INFORMATION ON PROGRAM PARTICIPATION AND OPERATION

At present, it is difficult to characterize what is happening in NRSA programs, regardless of the type, level, or field of training. For example, we cannot readily provide profiles on the basic demographic characteristics of predoctoral and postdoctoral fellows and trainees, the characteristics of institutions receiving NRSA awards, the types of training models and activities being supported, the components of NRSA training that distinguish it from other training programs aimed at producing researchers in the same fields, and so forth. This dearth of knowledge not only handicaps our ability to understand the basic components of the NRSA program, but it also hampers designing studies that can better assess outcomes (and, ultimately, the effects) of NRSA training and identify with greater confidence which types of training strategies may work better than others (e.g., multidisciplinary programs versus those that focus on one discipline or specialty).

Efforts need to be initiated to rectify this situation. Although retrospective studies of former trainees and fellows have provided useful insight into training gaps and deficiencies (e.g., Gentile et al., 1987), they are limited. Surveys of recent Ph.D.s and M.D.s/Ph.D.s upon receipt of their doctorate could provide some preliminary insight into the types of variables that should be examined and how they can be measured best (e.g., the phrasing of survey questions, if appropriate). The same can be said for surveys of NRSA-supported postdoctoral trainees and fellows who have just completed their postdoctoral appointment.

The most preferred strategy is to collect data from individuals at key intervals during the training process so as to avoid the problems of selective memory and to obtain a more complete picture of how and when training actually occurs. Such efforts also could provide data on many other issues. Program implementation could be examined (i.e., did individuals actually receive the training set forth in the funded application?). If information on trainee satisfaction were collected, the need for modifications in training policies or regulations also might be identified. Finally, if such efforts were extended to a sample of predoctoral students or postdoctoral associates without traineeships in the same academic program and possibly to students in similar programs in departments without training grants, we would begin to develop a better sense of the strength and integrity of various NRSA "treatments" (e.g., whether NRSA programs provide training experiences sufficiently different from those received by students in the same program or in other programs).

The manner in which trainees are selected is another important area worthy of close scrutiny. We know, at least for the biomedical sciences, that predoctoral trainees tend to receive their training in top-ranked institutions/departments; presumably, the training grant application review process is selecting the best programs, and the departments in which these programs are based are highly selective in terms of graduate student admitting policies.[7] However, we do not know whether those who actually receive traineeships are awarded them because they are the best "match" in terms of the requirements of the NRSA-supported program, because it is a convenient source of money at a particular period of time, or for other reasons. The same problem plagues applicants for postdoctoral appointments, particularly in medical schools. Needless to say, the ability to ultimately provide answers to questions seeking evidence on effectiveness is hampered by our lack of knowledge about how individuals are selected to receive NRSA support.

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[7] These programs have been described as "contests" (Rossi, personal communication, May, 1989) in that the most promising applicants are chosen to receive awards. It appears that the main contestants are institutions; the top-ranked research universities clearly are given preference. However, within the departments that house the NRSA programs, it is not clear whether the contest rules are the same, given the problems described in

## INCREASED ATTENTION TO ASSESSING PROGRAM OUTCOMES

Those associated with NRSA programs, particularly at the program administrative level, want to know what works best in research training, either in terms of specific training models (e.g., broad versus specialized training) or in terms of specific populations (e.g., predoctoral support versus postdoctoral support versus both types of support in producing physician/ scientists). Previous large-scale evaluation efforts that have had to rely on retrospective assessment strategies have been unable to confidently provide unequivocal answers to these questions because of the problems associated with drawing solid comparison groups. Given this substantial interest in program outcomes, particularly comparative outcome data, concerted attention should be devoted to examining the full range of outcomes implied by the goals of the NRSA program (i.e., both research and teaching activities as specified in program announcements and payback requirements for NRSA programs) and to pilot testing new data collection strategies. The issues and variables warranting consideration are discussed by Fox (1983) and Gee (1989) and should be guided by previous research on scientific careers (e.g., Long et al., 1979; McGinnis et al., 1982; McGinnis and Long, 1988; Stephan, 1986). Not only would efforts to accurately measure outcomes and test various measurement strategies help to better examine scientific productivity and career development, but they also would allow an understanding of the marginal gain associated with using these measures as contrasted to those previous approaches that have had to rely on existing archival data bases.

Outcome assessments also could benefit from efforts geared at improving the use of existing archival data bases. For example, rather than using archival data bases to obtain a "snapshot" at one point in time of research grant success, the feasibility of using such data bases to track individuals over time, similar to that performed by Biddle et al. (1989) in

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this paper. This area requires further investigation, modeled on the work by Carter et al. (1987) for Research Career Development Awards.

examining the career accomplishments of Research Scientist Development awardees, could be explored. Another possibility would be to assess the feasibility of using relevant data from other archival sources that could augment the information on traditionally used measures (e.g., research grant success) or provide data on outcomes that have received only minimal attention (e.g., teaching others to be researchers). For example, Yasumura (1986) found that recipients of the K0-6 awards were more likely to receive PHS training grants--a relevant outcome, based on the request made by Congress for obtaining information on the number of awardees who engage in health research or teaching as a career (P.L. 99-1258).

In addition, exploring relationships between program characteristics and outcomes also is needed. For example, recent data on NHLBI awardees suggest that those M.D.s who were postdoctoral trainees in programs designed to train both M.D.s and Ph.D.s were more likely to be receive a NIH grant than those who were postdoctoral trainees in programs only aimed at M.D.s (C. Roth, personal communication, June, 1989). More efforts of this kind can guide subsequent outcome studies in terms of identifying key programmatic variables that should be considered.

Another focus should be on designing outcome studies where the entire "dosage" of training is measured. At the very least, for outcome studies of ADAMHA, NIH, or other PHS support, this information should be available from the TFF currently in existence. However, given that NRSA research training is just one part of funding for scientific personnel development, measuring the length of training must take into account all types of research training and development (e.g., short-term research training, predoctoral and postdoctoral traineeships and fellowships, and career development awards). If the previously described efforts for developing and/or reinstituting data bases on personnel working on PHS grants also are initiated, this would provide additional information on dosage by getting data on predoctoral or postdoctoral support financed by faculty research grants from these agencies. The completeness and accuracy of this information then could be checked by actually contacting the individuals chosen for examining outcomes to determine what types of training support they actually received--both from PHS and other sponsors.

The final point is a call for evaluation efforts that incorporate a more longitudinal perspective. To date, the majority of the studies have been of the snapshot variety--career accomplishments at one point in time. Future evaluation activities ideally must track individuals from the time they begin training (or apply for training opportunities) through the completion of their training and during their scientific careers. Even more limited efforts would benefit from following the Carter et al. (1987) and Biddle et al. (1988) approach to measuring outcomes (e.g., PHS research grant activity) at several points after the individual has completed training. Only within a longitudinal perspective can a specific achievement or pattern of achievements be interpreted and yield information that can illuminate our understanding of these programs and research training in general.

## INCREASING THE AVAILABILITY OF RESOURCES FOR RESEARCH ON RESEARCH TRAINING

Developing better outcome strategies is at least partially dependent on better understanding the nature of scientific careers, what influences productivity, and other similar relationships. Currently, funding for research on scientific careers, resources, and so forth is not abundant. The NSF's Division of Science Resources devotes some funds to supporting studies in these areas (e.g., National Science Foundation, 1986). However, monies for this program are limited, and proposals often must include all scientific and engineering fields rather than those most relevant to NRSA programs or must focus on using preexisting survey data collected by NSF (data that typically includes, for example, only small numbers of NRSA-supported individuals in various categories).

Research on scientific career development and enhancement can go a long way toward addressing basic questions about productivity, motivations for choosing a scientific career, the factors that facilitate or inhibit research productivity, and so on. In conjunction with these research programs, efforts need to be targeted at developing new measures of scientific productivity and quality of research and testing their feasibility. Work on assessing the quality of training programs, apart from the accomplishments of their graduates, is another component that requires attention, particularly if future evaluation efforts aimed at judging the quality of training grant recipients (i.e., programs/departments within institutions) are considered worthy of exploration.

The list of research questions is endless, and reasonably strong arguments could be made for choosing any particular question or methodological strategy as the initial starting point. The major point is that resources for these efforts should be increased so that our ability to carry out evaluation activities that can both meet the needs of major NRSA constituencies and assist in the continual improvement of training activities in all fields of health-related research can be enhanced.

## EXPLORING THE FEASIBILITY OF EVALUATION DESIGNS FOR ASSESSING EFFECTIVENESS

Given our lack of knowledge about the nature of the selection and training processes, improving the quality of future designs certainly represents a technical challenge. Perhaps the first step toward obtaining better estimates of the relative effectiveness of different types of research training programs and determining the training strategies or mechanisms that work best is to identify where the use of high quality designs can be implemented.

One way to begin this process is to focus initially on exploring opportunities that may exist for assessing specific components. For example, the MSTP appears to be a promising candidate for consideration, given that training program directors often vigorously recruit students. Thus, a pool of applicants may be available to use as a comparison group. The feasibility of "beating the bushes" to augment the size of the applicant pool, of convincing directors to collect necessary data on applicant characteristics, and of persuading them to adhere to a standard selection process and criteria should be explored. Even if random assignment is not possible (a likely event), the use of such designs as regression-discontinuity is worth examining. This latter type of design was used successfully in Carter et al.'s (1987) evaluation of the Research Career Development Award.

In addition, exploring the feasibility of implementing high quality evaluation designs for the MST program is attractive, given the level of interest in this component. For example, some concern has been expressed over the available supply of physician-researchers, and MD-Ph.D. training programs are being established by other agencies to resolve this problem. At the same time, however, the best way to produce physician-scientists is a point of controversy. Further, questions have been raised about the fact that the total expenditures per graduate for MST programs have been increasing over the last decade and are now significantly higher than for graduates supported by other predoctoral training grants (National Research Council, 1983). Well-designed evaluations of the MST program, focusing on the outcomes of its graduates and its effectiveness on certain outcomes and as compared to other research training alternatives for physician-scientists, would do much towards addressing these issues.

The lower level of interest in effectiveness questions expressed by constituencies, coupled with the difficulty in carrying out high quality studies to address these questions, does not, however, imply that exploring the feasibility of implementing rigorous designs for estimating program effects is not important. The long-term objective for NRSA evaluation efforts should be to gain an understanding of what works in training, which programs and program elements work better, and how training should be assessed. Small-scale, pilot tests of more rigorous approaches can be quite instructive in terms of identifying where more better designs can be implemented and ultimately yield an understanding of research training itself.

Many of the concerns being expressed today (e.g., future shortages of trained scientists, issues of scientific misconduct, and the lack of interdisciplinary research efforts in many major problem areas) have their core issues surrounding human resources and training. If we are successful in providing a better understanding of NRSA research training and how it operates and contributes to the development of outstanding researchers and research mentors, one step toward addressing these issues will have been taken.

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## APPENDIX A
## EVALUATION QUESTIONS ASKED BY MAJOR NRSA CONSTITUENCIES

| Type of Question | Congress | NIH/ADAMHA Staff |
|---|---|---|
| **Demand for the Program** | What is the Nation's overall need for biomedical and behavioral science personnel?* | How many clinical researchers are needed to address major health problems over the the next decade? |
| | In which fields and research areas are investigators most needed? How many training slots are needed to address these shortages? | What is the need for scientists who work problems related to drug abuse? How many are needed to address particular issues (e.g., neuromechanisms of drug action? |
| | Who are the major sponsors of research training? | How much postdoctoral research training is supported by mechanisms other than NRSA? |
| | What role does industry play in supporting research training? What should its role be? | Are there more high quality NRSA applications that can be supported with existing funds? |
| | If the NRSA program was terminated, would the remaining research training programs adequately meet the need for biomedical and behavioral scientists?* | |
| | Why should NRSA funding levels be increased when there are complaints as to the insufficient amount of research monies available to fund all high quality research grant applications? | |

## APPENDIX A (Continued)
## EVALUATION QUESTIONS ASKED BY MAJOR NRSA CONSTITUENCIES

| Type of Question | Congress | NIH/ADAMHA Staff |
|---|---|---|
| **Program Participation** | How many individuals receive NRSA awards each year?** | How many individuals receive NRSA fellowships vs. traineeships? |
| | What does the pool of applicants look like, and has it changed over time in terms of demographics and quality? | How many women and minorities are being supported by NRSA? |
| | How many individuals are supported in each of the research fields targeted as shortage areas? | In what types of institutions are individuals being trained? |
| **Program Characteristics and Operation** | Does the payback requirement function as a disincentive to individuals who would be qualified for NRSA support? Has this requirement affected the number and quality of applicants?** | Is the payback requirement structured appropriately? In particular, should not MDs who are supported for shorter periods of time (e.g., less than 12 months) be required to pay back NRSA funds, given that they may be less likely to be active researchers? |
| | Does the payback requirement have any effect on keeping NRSA recipients active in research for longer periods of time?** | What criteria are actually applied by Institutional Review Groups in recommending training grant applications for funding? Are these criteria consistent with what we know about the characteristics of successful training programs? |
| | Do current stipend levels affect the attractiveness of NRSA awards to potential recipients? | |

## APPENDIX A (Continued)
## EVALUATION QUESTIONS ASKED BY MAJOR NRSA CONSTITUENCIES

| Type of Question | Congress | NIH/ADAMHA Staff |
|---|---|---|
| **Program Characteristics and Operation (continued)** | What modifications are required in NRSA policies to meet the need for research personnel? | How are individual trainees actually selected by training grant directors? Is this prcess uniform across programs in the same field or research area?<br>What types of training are awardees actually receiving (e.g., formal courses and "hands-on" research experience?<br>Are the awardees actually being trained to be independent researchers or are they simply being utilized as "hired hands" in faculty laboratories? |
| **Program Outcomes and Effectiveness** | What are the kinds of research positions available to and held by NRSA awardees?*<br>How many NRSA awardees have careers in health research or teaching?**<br>How effective is the NRSA program compared to other research training programse, e.g., those operated by NSF? | What happens to NRSA awardees?<br>Do awardees go on to have active research careers in areas relevant to the mission of the sponsoring agency (e.g., drug abuse research)?<br>What works best in training physician-researchers (e.g., MD/PhD programs or extramural postdoctoral traineeships)? |

## APPENDIX A (Continued)
## EVALUATION QUESTIONS ASKED BY MAJOR NRSA CONSTITUENCIES

| Type of Question | Congress | NIH/ADAMHA Staff |
|---|---|---|
| **Effectiveness of Program Components** | How effective is the training grant mechanism in encouraging individuals to engage in health research and training careers?** | Is broad-based or specialty training the best way to produce researchers, in a specific disease area? |
| | | Which types of programmatic strategies work best in training grants? |
| **Cost-effectiveness of NRSA Programs** | | How can an agency best spend its "training buck?" |
| | | What is the cost of training researchers and then not utilizing them due to problems with insufficient R01 grant funds? |
| **"Research" on Research Training** | What is the best way to produce clinical researchers? | How long can we expect a scientist to be actively involved in research? |
| | What is the best way to attract undergraduates to pursue PhDs in a biomedical science? | What attracts a student to pursue a degree in a biomedical science? |
| | | What are the key "choice points" in deciding to pursue a career in science vs. in other areas? |

## APPENDIX A (Continued)
## EVALUATION QUESTIONS ASKED BY MAJOR NRSA CONSTITUENCIES

| Type of Question | Congress | NIH/ADAMHA Staff |
|---|---|---|
| **"Research" on Research Training** | What is the relationship between research training activities and producing quality investigators? | How can the "best and the brightest" into scientific careers?<br>What are the components of scientific productivity and how do these change over time? What does this mean for how the outcomes of NRSA programs should be measured?<br>In evaluating research training programs, what are the most appropriate outcome measures to use? |

Note. Unless otherwise indicated, the source of these questions were interviews with Congressional staff and individuals in charge of training programs at NIH and ADAMHA ($N$=16 interviews).

*Question is specified in the language of P.L. 100-607.

**Question is specified in the language of P.L. 99-1258.

# APPENDIX B

For the purposes of this paper, certain basic criteria were used to identify the evaluation studies chosen for review:

- The focus of the study was on NRSA programs. Studies of research training in general (e.g., Zumeta, 1983), although their populations may have included NRSA awardees, were not included as formal evaluations of these programs.

- "Data books" such as those produced by NIH (1988) and ADAMHA (1989a) were not classified as formal evaluations depite the fact that they provide data on number of awards and fundings levels. This type of document, however, is considered when discussing the availability of information on major evaluation questions (e.g., levels of program participation).

- The results had to exist in a form that was available for at least limited dissemination. All studies presented in Appendixes C and D were either formal published reports or reports prepared for internal and/or limited distribution (upon requested to interested parties). Other evaluation-related activities for which no "write-up" was available (e.g., computer printouts for which results were not summarized or informal staff attempts to gather preliminary data on outcomes of awardees) were not considered. They are, however, discussed in the paper, where appropriate.

Sixteen individual evaluation efforts met these criteria, and the major characteristics of each are summarized in Appendixes C and D. Appendix C presents information related to the coverage of each study in terms of: (1) the agency administering the programs (i.e., NIH or ADAMHA); (2) whether the study focused on a particular program or specific institute (e.g., NIMH); (3) the major category of training evaluated (e.g., predoctoral vs. postdoctoral); (4) whether the focus of the program was on training MDs, PhDs, or undergraduates; (5) the major fields of scientific training incorporated (e.g., biomedical vs. clinical sciences); (6) the time period examined (e.g., 1978-81 awardees); and (7) the major questions addressed by the evaluation.

In Appendix D are described selected methodological characteristics so as to better depict how evaluations were conducted and identify how program outcomes and/or effects were examined, given that the majority of studies reviewed attempted to address these types of questions.

APPENDIX C

## EVALUATION STUDIES OF THE NATIONAL RESEARCH SERVICE AWARD PROGRAM

| Study and Year | Major Characteristics |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | Major NRSA |  | Focus on Specific Inst/Program |  | Level of Training |  |  | Types of Degree Programs |  |  | Major Fields Included[a] |  |  |  | Years Included (19__) | Major Questions[b] |  |  |  |  |
|  | NIH | ADAMHA | Yes | No | Und | Pre | Post | PhD | MD | Other | Bio | Clin | Beh | Oth |  | Part Chars | Prog Oper | Outc Efft | Comp Efft | Cost Efft |
| **EVALUATION ACTIVITIES BY NAS** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Coggeshall & Brown | X |  |  | X |  | X |  | X |  |  | X |  |  |  | 67-81 PhD recipients | X | X | X* |  |  |
| Garrison & Brown, 1986 | X |  |  | X |  |  | X | X | X |  | X | X |  |  | 61,66,71, 76,81 PhD recipients 65,68,71,74, 77 MD recipients | X | X | X* | X |  |
| National Research Council, 1976 | X |  |  | X |  | X | X | X | X |  | X | X | X | X | 38-72 NIH awardees Scientists and MDs as of 1970 | X | X | X* | X |  |
| National Research Council, 1977 | X | X X |  | X |  | X |  | X |  |  | X |  | X | X | 71-75 PhD recipients NRSA awardees in health services research |  |  | X |  |  |
| National Research Council, 1978 | X | X |  | X |  | X |  | X |  |  | X |  | X |  | PhD granting programs as of 1975 |  | X | X |  |  |

## APPENDIX C

## EVALUATION STUDIES OF THE NATIONAL RESEARCH SERVICE AWARD PROGRAM (Continued)

|  | Major Characteristics |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Study and Year | Major NRSA Sponsor |  | Focus on Specific Inst/Program |  | Level of Training |  |  | Types of Degree Programs |  |  | Major Fields Included[a] |  |  |  | Years Included (19__) | Major Questions[b] |  |  |  |  |
|  | NIH | ADAMHA | Yes | No | Und | Pre | Post | PhD | MD | Other | Bio | Clin | Beh | Oth |  | Part Chars | Prog Oper | Outc Efft | Comp Efft | Cost Efft |
| National Research Council, 1981 | X |  |  | X |  | X |  | X |  |  | X |  |  |  | PhD granting programs that lost NIH support in 79-80 |  |  |  | X |  |
| Garrison & Brown, 1985 | X |  | X<br>URHP |  | X |  |  |  |  | X | X |  | X |  | 77-84 program participants and institutions | X | X |  | X* |  |
| **EVALUATION ACTIVITIES BY NIH** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| NIH, Division of Program Analysis, 1986 | X |  |  | X |  |  | X | X | X |  | X | X |  |  | 64-77 PhD recipients<br>68,71,74 MD recipients | X | X | X* | X |  |
| Velletri et al., 1985 | X |  |  | X |  | X |  | X |  |  | X |  |  |  | 67-74 PhD recipients | X | X |  | X |  |
| Sherman, 1984 | X |  | X<br>Short-Term |  |  | X |  |  | X | X |  | X |  |  | 78-80 NIH awardees<br>82-83 senior year medical students |  |  |  | X |  |
| National Institute of Dental Research, 1987 | X |  | X<br>NIDR |  |  |  | X | X | X | X<br>DDS/DMD<br>DDS/DMD-PhD | X | X | X | X | All NIDR awardees | X |  | X | X |  |

# APPENDIX C

## EVALUATION STUDIES OF THE NATIONAL RESEARCH SERVICE AWARD PROGRAM (Continued)

| Study and Year | Major Characteristics<br>Major NRSA<br>NIH | <br><br>ADAMHA | Focus on Specific Inst/Program<br>Yes | <br>No | Level of Training<br>Und | <br>Pre | <br>Post | Types of Degree Programs<br>PhD | <br>MD | <br>Other | Major Fields Included[a]<br>Bio | <br>Clin | <br>Beh | <br>Oth | Years Included (19__) | Major Questions[b]<br>Part Chars | <br>Prog Oper | <br>Outc Efft | <br>Comp Efft | <br>Cost Efft |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EVALUATION ACTIVITIES BY ADAMHA** | | | | | | | | | | | | | | | | | | | | |
| Schneider, 1980 | | X | X<br>NIMH | | | X | X | X | | | | | X<br>Psych | | 68-78 PhDs from NRSA programs in psychology | | | X | | |
| Clouet, 1986 | | X | X<br>NIDA | | | X | X | X | | | X | | X | X | 73-84 NRSA awardees | X | | X | X | |
| ADAMHA, 1986 | | X | | X | | X | X | X | | | X | X | X | X | 67-83 NRSA awardees | X | | X | | |
| **EVALUATION ACTIVITIES BY OTHER SPONSORS** | | | | | | | | | | | | | | | | | | | | |
| Sherman, et al., 1981 | X | | X<br>MSTP | | | X | X | | | X<br>MD-PhD | | X | | | 68-73 MD recipients | | | | X* | |
| Bickel, et al., 1981 | X | | X<br>MSTP | | | X | | | | X<br>MD-PhD | | X | | | 79 MD-PhD recipients<br>79 MD-PhD students & "drop-outs"<br>76 MSTP applicants | | X | | X | |

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[a] Although field definitions differ slightly across studies and NRSA sponsors, these field categories are generally described as follows: Biological sciences (includes fields in the basic biomedical sciences such as anatomy, genetics, and microbiology); clinical sciences (includes fields where the typical degree is a MD, DDS, and DMD such as internal medicine, psychiatry, or dentistry); behavioral sciences (e.g., psychology, sociology, or anthropology); and other (e.g., health services research and nursing research).

[b] Key to abbreviations:

| | | |
|---|---|---|
| Part Chars | - | Questions concerning levels of participation in the program or characteristics of participants. |
| Prog Oper | - | Questions about program operation (e.g., length of support provided, amount of support, and types of training received). |
| Outc Efft | - | Questions concerning program outcomes/effectiveness (e.g., career outcomes of awardees and effectiveness of NRSA). |
| Comp Efft | - | Questions about outcomes and/or effectiveness of specific components or programs within the overall NRSA program (e.g., programs administered by a certain NIH institute or distinct types of training programs such as MSTP). |
| Cost Efft | - | Questions concerning cost effectiveness. |

*Indicates an attempt to look at effectiveness through the use of either methodological or statistical procedures.

APPENDIX D

## EVALUATION STUDIES OF THE NATIONAL RESEARCH SERVICE AWARD PROGRAM: SELECTED METHODOLOGICAL CHARACTERISTICS

| Study and Year | Study Groups | Consideration of Pre-Award Differences | Types of Outcomes Studies | Type of Study | Major Questions |
|---|---|---|---|---|---|
| | | | **EVALUATION ACTIVITIES FOR NAS** | | |
| Coggeshall & Brown, 1984 | o PhDs who had 9 or more months of NIH predoc support<br>o PhDs trained in departments with NIH predoc support but who received 0-8 months of NIH support<br>o PhDs trained in departments that had no NIH predoc funding | Multiple regressions for selected outcome variables, using:<br>o years since PhD<br>o prestige of PhD institution<br>o years of NIH predoc support | o Attainment of doctorate<br>o Postdoctoral training<br>o Early career employment (academic positions and involvement in research)<br>o Pursuit of NIH and NSF research grants<br>o Publications and citation | o Retrospective<br>o Based on existing data bases<br>o Population data for some outcomes | o How successful are NIH predocs in pursuing careers in biomedical research?<br>o What is the relative importance of NIH predoc support in explaining outcomes?<br>o Are there any "era" effects?<br>o Do outcomes vary among specific NIH institutions?<br>o Has the NRSA program changed over (e.g., numbers of awards made by institutions?) |
| Garrison & Brown, 1986 | For PhDs:<br>o NIH postdoc Fellows<br>o NIH postdoc Trainees<br>o PhD recipients for same time period who indicated plans for non-NRSA postdoc<br>o PhD recipients for same time period who indicated "no postdoc plans" | Multiple regressions for selected outcomes, using:<br>o Years to PhD<br>o Prestige of PhD granting department<br>o Selectivity of baclaureate institution<br>o Study group membership | o Employment (academic positions and involvement in research)<br>o Pursuit of research grants from NIH, NSF, VA, and selected private sponsors<br>o Publications and citations | o Retrospective<br>o Based on existing data bases<br>o Population data for some outcomes | o How successful are NIH postdocs with PhDs in pursuing biomedical research careers?<br>o Are there differences in outcomes for NIH trainees vs. NIH fellows?<br>o Are there "era" effects?<br>o Has the program changed over time?<br>o What are the characteristics of awardees? |
| | For MDs:<br>o NIH postdoc Fellows<br>o NIH postdoc Trainees<br>o Those with no NIH postdocs who reported involvement in teaching/research<br>(Continued on next page) | Multiple regressions for selected outcomes, using:<br>o Prestige of medical school granting MD<br>o Employment in medical school | o Medical school employment<br>o Pursuit of research grants from NIH, NSF, VA, and selected private sponsors)<br>o Publications and citations | o Retrospective<br>o Based on existing<br>o Population data for some outcomes | o How successful are NIH postdocs with MDs in pursuing biomedical research careers?<br>o Are there differences in in outcomes for NIH Trainees vs NIH Fellows?<br>(Continued on next page) |

APPENDIX D (Continued)

## EVALUATION STUDIES OF THE NATIONAL RESEARCH SERVICE AWARD PROGRAM: SELECTED METHODOLOGICAL CHARACTERISTICS

| Study and Year | Study Groups | Consideration of Pre-Award Differences | Types of Outcomes Studies | Type of Study | Major Questions |
|---|---|---|---|---|---|
| Garrison & Brown, 1986 (Continued from previous page) | o Those with no NIH postdocs and who reported primary involvement in "other" activities | o Study group membership | | | o Are there differences in outcomes for those with NIH intramural training?<br>o Are there any "era" effects?<br>o What are the characteristics of awardees? |
| | AND | | | | |
| | o NIH Trainees who had intramural res. appt.<br>o NIH Fellows who had intramural res. appt.<br>o Intramural appointees only<br>o Extramural NIH Trainees only<br>o Extramural NIH Fellows only<br>o No NIH extramural or intramural apts. | | SAME AS ABOVE | | |
| National Research Council, 1986 | For PhDs:<br>o NIH postdocs<br>o NIH predocs who had no postdoc support<br>o PhDs with no pre- or postdoc support<br>o Those who did not receive the PhD<br>For MDs:<br>o MD-PhDs who also had NIH postdocs<br>o MD-PhDs who had no NIH postdocs<br>o MDs with NIH postdocs<br>o MDs with no PhD or postdoc training | None | o Attainment of doctorate<br>o Academic employment<br>o Primary work activity (e.g., research, training, or administration)<br>o Publications and citations | o Retrospective<br>o Use of existing data bases<br>o Site visits to departments | o How successful are NIH progress in encouraging and promoting biomedical research/training careers?<br>o Does the mechanism of support affect the outcomes?<br>o What are the characteristics of awardees?<br>o How have training monies been used by programs and what are need improvements?<br>o What are the characteristics of the programs (e.g., stipend levels)? |

APPENDIX D (Continued)

## EVALUATION STUDIES OF THE NATIONAL RESEARCH SERVICE AWARD PROGRAM: SELECTED METHODOLOGICAL CHARACTERISTICS

| Study and Year | Study Groups | Consideration of Pre-award Differences | Types of Outcomes Studies | Type of Study | Major Questions |
|---|---|---|---|---|---|
| National Research Council, 1977 | o PhDs who were NRSA awardees<br>o PhDs awarded during the same time period but who did not receive NRSA support<br>o Pre- and postdoc awardees of NRSA programs related to health services research | None | o Postdoctoral training<br>o Employment sector<br>o Research activity (time, spent in research, health-relatedness, and source of support)<br>o Time spent in other types of activities (e.g. teaching and service)<br>o Attitudes toward relevance of degree and research training | o Sample survey to PhD recipients | o What were the career outcomes of NRSA awardees in biomedical and behavioral sciences?<br>o What were the career outcomes for NRSA services research? |
| National Research Council, 1978 | o PhD granting departments | Responses were analyzed by institutional quality, control, type, department age, and existence of training grant. | o Changes in student population<br>o Changes in program activities<br>o Changes in quality of training activities<br>o Changes in departmental resources (e.g., student aid) | o Survey to PhD-granting departments<br>o Site visits | o What is the role of federal funds in graduate training?<br>o What is the impact of lost training support on departments?<br>o What is the state of the labor market? |
| National Research Council, 1981 | o Programs that had lost NIH support | Not applicable | o Changes in student population<br>o Changes in program activities<br>o Changes in quality of training | o Site visits | o What is the impact of lost training support on departments? |
| Garrison & Brown, 1986 | o Institutions with MARC programs<br>o Those without MARC programs<br>o Career plans | | o Biological sciences degrees awarded by institutions<br>o Participant satisfaction<br>o MARC curriculum<br>o Career plans<br>o Career attainments | o Survey of former program participants<br>o Site visits to programs | o What are the characteristics of the Honors Undergraduate Research Training Program?<br>o What are the characteristics and outcomes of students?<br>o What is the program's impact on participating institutions, particularly in terms of improving science curricula? |

APPENDIX D (Continued)

EVALUATION STUDIES OF THE NATIONAL RESEARCH SERVICE AWARD PROGRAM: SELECTED METHODOLOGICAL CHARACTERISTICS

| Study and Year | Study Groups | Consideration of Pre-Award Differences | Types of Outcomes Studies | Type of Study | Major Questions |
|---|---|---|---|---|---|
| **EVALUATION ACTIVITIES FOR NIH** | | | | | |
| NIH, Office of Planning & Program Analysis, 1986 | For MDs:<br>o NIH postdoc Fellows<br>o NIH postdoc Trainees<br>o Unsuccessful applicants for NIH Fellowships<br>o Those who did not apply for NIH fellowships | None | o Medical school employment<br>o Pursuit of NIH/ADAMHA research grants | o Retrospective<br>o Use of existing data bases | o How did the number and quality of fellowship applicants change after instituting payback requirement?<br>o Did the NRSA program affect the number of persons in health research/teaching careers?<br>o Do NRSA recipients pursue health research/training careers? |
| | For PhDs:<br>o NIH postdoc Fellows<br>o NIH postdoc Trainees<br>o Those with "postdoc plans but no NIH postdoc appointments<br>o Those with "no plans" for postdocs | None | o Academic employment<br>o Time spent in research and teaching<br>o Pursuit of NIH/ADAMHA research grants | | o How effective are training grants in encouraging health research careers? |
| Velletri et al., 1985 | o NIH predoc Trainees<br>o NIH predoc Fellows | None | o Attainment of PhD<br>o Postdoctoral training<br>o Early career employment (academic positions and involvement in research)<br>o Pursuit of NIH and NSF research grants<br>o Publications and citations | o Retrospective<br>o Based on existing data bases<br>o Population data for some outcomes | o Are there differences in the outcomes of NIH trainees vs. NIH fellows?<br>o Do the results of these comparisons change over time? |

## APPENDIX D

### EVALUATION STUDIES OF NATIONAL RESEARCH SERVICE AWARD: METHODOLOGICAL CHARACTERISTICS (Continued)

| | Major Characteristics | | | | |
|---|---|---|---|---|---|
| Study and Year | Study Groups | Consideration of Pre-Award Differences | Types of Outcomes Studies | Type of Study | Major Questions |
| National Institute of Dental Research, 1987 | o NIDR postdocs Trainees<br>o NIDR postdoc Fellows<br>For NIDR Postdocs:<br>o DDS-PhD/DMD-PhD<br>o PhDs only<br>o DDS/DMD only | None | o Employment<br>o Pursuit of NIH and NIDR research grants<br>o Pursuit of NIDR research grants | o Retrospective<br>o Based on existing data bases<br>o Population data | o How successful are NIDR postdocs in pursuing research careers?<br>o Do the outcomes differ for Trainees vs. Fellows?<br>o What are the characteristics of awardees?<br>o What are the characteristics of the training sites for awardees?<br>o What is the relationship between type of degree and extent of postdoc training to obtaining subsequent NIDR research funding? |
| Sherman, 1984 | o Awardees of NIH short-term training funds<br>o Those who had not received NRSA short-term training | None | o Research experience in medical school<br>o Post-graduation employment and research training plans<br>o Career preferences and expectations<br>o Debt upon graduation<br>o Pursuit of NIH research grants | o Based on existing data bases | o How many short-term trainees have been supported?<br>o How many short-term trainees eventually applied for and/or received NIH grants?<br>o Do the research plans of former trainees differ from non-trainees? |
| **EVALUATION ACTIVITIES OF ADAMHA** | | | | | |
| Schneider, 1980 | o Predocs and postdocs who had received NRSA awards in psychology from NIMH | None | o Postdoctoral training<br>o Initial employment position | o Survey of training program directors | o What are the initial employment positions of former NRSA awardees from psychology programs? |

## APPENDIX D

### EVALUATION STUDIES OF NATIONAL RESEARCH SERVICE AWARD: METHODOLOGICAL CHARACTERISTICS (Continued)

| | Major Characteristics | | | | |
|---|---|---|---|---|---|
| Study and Year | Study Groups | Consideration of Pre-Award Differences | Types of Outcomes Studies | Type of Study | Major Questions |
| ADAMHA, 1986 | o ADAMHA predocs<br>o ADAMHA postdocs<br>o Those receiving both | None | o Receipt of ADAMHA/NIH research grants | o Retrospective<br>o Based on existing data bases | o How many individuals received training support?<br>o How many subsequently received ADAMHA/NIH grants?<br>o How many ADAMHA research grantees received training support? |
| Clouet, 1986 | o NIDA Trainees<br>o NIDA Fellows | None | o Career quality (composite) rating of promotion rate, employer prestige, and awards)<br>o Research quality (composite rating of papers, awards and presentation)<br>o Type of employer | o Survey of awardees<br>o Existing trainee files | o How successful are NIDA awardees in pursuing biomedical research careers? |
| EVALUATION ACTIVITIES BY OTHER SPONSORS | | | | | |
| Sherman et al., 1981 | o MSTP graduates<br>o NIH Intramural Clinical Associates<br>o NIH Intramural Research Associates<br>o NIH Extramural Postdocs | Comparison groups were matched matched on sex, age, type of medical school, period of training, and MCAT scores. | o Employment positions<br>o Pursuit of NIH research grants<br>o Publications | o Retrospective<br>o Based on existing data bases<br>o Survey to comparison group members | o How successful were graduates in pursuing medical research/teaching careers? |

## APPENDIX D

## EVALUATION STUDIES OF NATIONAL RESEARCH SERVICE AWARD: METHODOLOGICAL CHARACTERISTICS (Continued)

| | Major Characteristics | | | | |
|---|---|---|---|---|---|
| Study and Year | Study Groups | Consideration of Pre-Award Differences | Types of Outcomes Studies | Type of Study | Major Questions |
| Bickel, et al, 1981 | o Those with MST support<br>o Those in other MD-PhD programs | None | o Attrition from MD-PhD Programs<br>o Applications to MST program | o Survey of medical deans | o Were those in MST more likely than those in other MD-PhD programs to complete the program?<br>o What are the characteristics of applicants to MST programs?<br>o How does the number of applications to MST programs compare with the number of available training slots? |

# PRODUCTIVITY

*Helen Hofer Gee**

## INTRODUCTION

In 1986 NIH contracted with the Institute of Medicine to organize a conference on research training. A central, though not explicitly stated, purpose of the conference was to obtain guidance on how to continue to meet Congressionally mandated requirements for periodic reports on the role of and need for research training in the biomedical and behavioral sciences. Ostensibly, the conference was concerned with

> an examination of how successfully research training has been conducted, which program mechanisms produce the most suitable training, and what information is required to enable further assessments of national needs for researchers in the decade ahead. [Listed first among three categories of issues requiring attention was] . . . measuring the productivity of scientists in their research programs and as reflections of their training. The issue in productivity is how to improve the measurement of it; simply gauging productivity by the current popular methods is inadequate for the task at hand. (Institute of Medicine, 1986)

Anyone who has ever been faced with the task of having to select among individuals--for employment, advancement, funding, awards--has dealt with the issue of assessing productivity and has, implicitly or explicitly, weighed available evidence of previous performance. The difficulty and complexity of these decisions may well underlie the malaise that is apparent in the committee report. The committee's more explicitly reported concerns with such measures as success in obtaining research grants, citation counts that ignore differences among and possibly within disciplines, and studies that fail to consider work environments suggest that the real problem lies not in the measures of productivity per se that have been used, but in how the measures have been used--that is, in the designs of assessments of training support programs.

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* The opinions expressed in this paper are the author's and do not necessarily reflect those of either the Committee on Biomedical and Behavioral Research Personnel or the National Research Council.

Unfortunately for those who seek quick solutions, concepts relevant to the measurement of productivity are inextricable from those concerning almost all other domains within the social study of science. Dealing directly with the problems of productivity measurement therefore requires cognizance of the state of the entire science. Any study, for example, that ignores differences among or within disciplines ignores more than three decades of intensive study of the entire social structure of science, not just the study of "productivity" per se.

> In the critical, scholarly essay, Gilbert (1978) noted that there is a reciprocal relationship between the theoretical framework which the social scientist brings to his work and the indicators which he will find most appropriate for his research . . . the adequacy of an indicator can only be assessed through a detailed study of the context in which the phenomena to be measured are embedded, and of the validity of the measurement theory on which it relies . . . this requirement is equivalent to the demand that we understand the functioning of the scientific community at a micro-level.

A small community of scientists (static in size in the United States since about 1980, but rapidly increasing in Western and Eastern Europe and Japan since the late 1970s) has been making significant progress in the direction Gilbert suggests (see Appendix and References). The most recent burst of research activity relevant to the assessment of productivity began when Martin and Irvine (1983) assessed basic research activity and programs (radio astronomy and physical sciences). Their papers specified "partial indicators" of scientific progress and investigated the extent to which these indicators "converge" to produce valid and reliable estimates of the productivity of designated groups of scientists. The work created a virtual storm of criticism, largely because it was so far-reaching (see Chubin, 1987). The continuing discussion has instilled new vigor into the development of the field.

The concept of multiple partial criteria was certainly not introduced by Irvine and Martin. Even Clark's study of the careers of psychologists (1957) incorporated the concept in a general sense. As noted by Jones et al. (1982), Weiss (1972) discussed them:

> At best each is a partial measure encompassing a fraction of the large concept . . . . Moreover, each measure [may contain] a load of irrelevant superfluities, "extra baggage" unrelated to the outcomes under study. By the use of a number of such measures, each contributing a different facet of information, we can limit the effect of irrelevancies

> and develop a more rounded and truer picture of program outcomes.

However, as Chubin (1987) concludes in his discussion of Irvine and Martin's work, it is

> . . . also politically astute, serving scholarly and policy communities. It explicitly anticipates criticism and sources of error, disarms skeptics, and gets an analytical foot in the right doors--those shielding the offices of policymakers who have come to rely on participant scientists and their own imprecise and self-serving devices for making decisions about who gets and who doesn't.

Moravcsik (1986) hailed the extensive debate and critiques of the Martin and Irvine work as a welcome sign--

> since it shows that the field has reached the state of maturity when its applications to concrete situations are sufficiently realistic to create a heated controversy, involving people from a variety of professional backgrounds.

He commented further that neither critics nor Irvine and Martin, in their response to critics, offered any specific suggestions for improvement. Moravcsik then proposed that some suggestions can be made and conclusions drawn concerning the need for future activities by relating the debate to another effort in science assessment--namely, a project organized by the United Nations Center for Science and Technology for Development (UNCSTD) and centered on a paper that Moravcsik was commissioned to write. Moravcsik reported further that at a meeting held in Graz, Austria, in May 1984 the paper was discussed:

> The UNCSTD project did not result in a set recipe for assessing science and technology. On the contrary, the project concluded that there is no such universal recipe, and hence that the aim should be to devise a process which, in any particular case, yields a methodology for an assessment.

## SUGGESTED OUTLINE FOR PLANNING STUDIES OF PRODUCTIVITY OR QUALITY

The proposed UNCSD process serves as a useful framework in which to present some thoughts about planning studies focusing on the assessment of productivity. The following list draws heavily and directly on Moravcsik's report:

1. Identify the goals of science that are to be taken into account. Moravcsik noted,

> . . . Science and technology have many different goals, aim and justifications, and in any particular case it must be specified which one (or which ones) of these are taken into account, and with what weight.

Studies of National Institutes of Health research training programs have ostensibly aimed at assessing a common goal of such programs--to wit, the production of trained scientists who will contribute to the advancement of the biomedical sciences. Prior to the mid 1970s, this was interpreted by some Institutes as including support for the clinical training of physicians in areas where the supply of expertise was felt to be inadequate. After it became clear that the majority of these individuals simply entered private practice, however, those programs were for the most part discontinued. Such discrepancies must, therefore, be given careful attention in planning studies of program outcomes. Since the mid '70s, NIH training programs in general have focused specifically and exclusively on research training. Assessment of the success of these research training programs have, however, interpreted the terms "contribute" and "advancement" quite narrowly. Teaching (either future researchers or practitioners), biomedical research administration, mentoring (i.e., guiding the graduate education of future researchers), and conducting research that does not seek external funding and research that cannot (because of the interests or concerns of the power structure within which it is conducted) be published have often been denied recognition as goal-relevant behavior. Consideration should be given to whether any of these professional activities should be explicitly recognized as contributing to the advancement of the biomedical sciences and, if so, studies should be designed to assess these kinds of productive endeavor.

2. Recognize the multidimensionality of goals, of potential pathways to them, and of methods of measuring outcomes; specify which dimensions and connections of the system are to be taken into account.

Once goals have been specified (and it is recognized that achieving those goals can and is likely to be expressed in different ways), study designs must allow for the varieties of pathways and outcomes that may occur. Cole and Cole (1973) set the stage for this type of inquiry in their cross-sectional analyses. The work of Long, McGinnis, and Allison (1979, 1981, 1982) examined many of the same "connections" as the Coles but, by following a cohort longitudinally, revealed a different sequence of career development. The Long and McGinnis work has been particularly notable in its pursuit of the significance of context, the multidimensionality of career pathways, and the changing significance of predictors in assessing productivity at stages in research career development. In another notable analysis of the NIH Research Career Development Program, Carter et al. (1987) examined both selection processes and outcomes using multivariate techniques to assess the significance of correlates and causal relations, as well as a sophisticated cohort selection procedure to control for disciplinary differences.

3. If, as is usually the case, it is not feasible to study all aspects of a system, specify which aspects are to be included and which will be omitted and indicate clearly the implications of these decisions for the assessment process.

Moravscsik provided an apposite illustration of one perspective:

> If, of two cars, one has a higher top speed, and the other a lower gasoline consumption per mile, it is not possible to say which is the 'better' car without ascribing some value judgment to high speeds versus economy in the use of fuel.

Two other examples come to mind: (1) if in planning a study of the effectiveness of a training program, it was decided that pursuit of a research career in the private sector was a favorable outcome but that assessing the performance of former trainees who followed that path was not feasible, they could be explicitly excluded from potential comparison cohorts; (2) if research administration is deemed a favorable outcome, those research administrators could be excluded from comparisons in which research publications were used as indicators and included where other measures of productivity, more suitable to their employment, were used. The guideline simply demands precise specification of the details of the design of an investigation.

4. Specify how the results of the assessment are to be used.

A study intended to assist program managers in their decisionmaking will seldom have the same design requirements as a study intended to inform policy decisions. If policy decisionmakers are to be informed, for example, the delineation of possible alternative indicators of productivity may be critical, whereas meeting program management needs may require more intensive analysis of only those that are the most direct manifestations of program goals. The key is to consider carefully the kinds of decisions that the study is intended to influence.

5. Select a set of indicators that will satisfy the requirements of each of the study design considerations. Recognize and specify the limitations of each of the indicators. To quote Moravscik,

> There are many types of indicators: input versus output; quantitative versus qualitative, indicators of activity, productivity, or progress; indicators of quality, importance or impact; there are functional and instrumental indicators; there are micro- and macro-indicators; there are "data-bases" and "perceptual" indicators; and so on. Some indicators are already 'on the shelf' and can be taken from it and used in new situations. More likely, however, the most appropriate indicators for a new situation need to be improvised for that particular situation. . . . Be reconciled to the fact that in any case, you will end up with a set of indicator measurements which, in general, cannot be reduced to a one-dimensional measure and hence to an unambiguous ranking.

It is apparent that the selection and/or development of indicators of productivity depend on the kinds of questions that are being asked and the perceived complexity of the system involved. An indicator that provides excellent explanatory data for one study may be useless in another context. Every measure, moreover, has limitations that may, under some conditions, obviate their utility and, in other circumstances, may be totally irrelevant. If a study plan is suitably mapped, it may not be feasible to use the same indicators of productivity for all individuals in a cohort. For example, if teaching undergraduate students is judged to be an acceptable outcome of research training, the productivity of an individual whose primary activity is teaching will not be appropriately assessed by counting that individual's production of research papers--but consideration might be given to using the production of review papers as one of several measures of performance in the educational domain. However, for some outcomes regarded as suitable expressions of the goals of an enterprise, no suitable approach to assessment "measurement" is available to evaluators. In such cases the individuals should be removed from comparison groups that are to be analyzed statistically rather than, as is often the case, counted a "failure" according to indicators that appropriately measure the productivity of other members of the group.

## MEASURES OF PRODUCTIVITY

The above overview should make it clear that any discussion of specific measures of productivity is necessarily superficial, simplistic, and incomplete because outside the context of the design of a specific study, there is not a great deal to be said about any particular measure. In addition, since productivity in one sense or another is the focus of most of the studies of the social science of science, a thorough literature review would require a few years of effort. Nonetheless, various measures that might be used in studies of productivity are discussed below. The discussion is intended to draw attention to complexities, issues, and problems in the use of these measures, knowledge of which might aid in carrying out the kind of careful approach to study design outlined earlier.

### Publication Counts

While it is generally agreed that the principal, or most prevalent, immediate outcome of the active research investigator's efforts is the preparation of papers published in professional journals and by 1982 a nearly 2600-item bibliography listing publications analysis items was available (Hjerppe, 1982), counts of publications continue to be derogated. Because the analysis of publications plays a dominant role in social studies of science, a complex, highly sophisticated methodology has been developed. The intellectual leader of modern-day social studies of science was Derek J. deSolla Price (1961, 1963). The early development of computer-based analytic methods, which have stimulated much of the sophisticated analysis characteristic of social analysis of science studies of the past two decades, resulted largely from the enterprise of two individuals: Eugene Garfield (1955) developed the *Science Citation Index* (SCI), on which most publications analysis work is dependent; Francis Narin and his associates at Computer Horizons took the lead in exploring and developing measures to maximize the utility of the wealth of information contained in the SCI. In 1969 (Narin, 1977) the area even acquired its own label--bibliometrics--to describe collectively quantitative, analytical studies of written communication.

In simplest terms, publication counts are no longer acceptable as a measure of productivity unless at least the following potential sources of error or misinterpretation are controlled or accounted for:

- differences among disciplines of cohort members,
- differences among journals in terms of measured influence (see section on journals page 131),
- differences in "quality" or "impact" as measured by citations or peer assessment (or journal influence),
- professional age of cohort members, and

- social context of cohort members.

Despite concerns about "loud noises from empty vessels," publication counts have been shown repeatedly to correlate positively with assessments of quality and to contribute useful independent variance to the assessment of productivity. Reported correlations between quantity and quality measures vary considerably among studies, between approximately $r = .23$ and $r = .80$; differences may relate to disciplines, characteristics of cohorts, or even to how quantity and quality of publications are measured.

In a series of studies conducted in the late 1970s (see Narin, 1983), numbers of publications by faculty and staff in universities and hospitals were shown to be extremely highly correlated with NIH funding ($r = .90$ to 95); and there were no economies or diseconomies of scale in the funding of research grants. Funding and publication relationships may appear to break down, however, when small aggregates of researchers or disciplines are assessed and especially when basic and clinical research publications are intermixed. Publication rates of basic scientists differ markedly from those of clinical scientists, who publish less frequently and whose research is usually very much more costly. When the funding and publication rates of small aggregates of subjects are investigated, the tendency is to ignore such disciplinary differences, thus ignoring an important moderating variable. With small aggregates other minor sources of error--such as idiosyncratic events that may affect the usual patterns of behavior of part of a group for a period of time--may also obscure an underlying relationship. When large aggregates and adequate time spans are employed, such obfuscating sources of error will usually cancel each other out, permitting stable, underlying relations to be revealed.

When a quick, inexpensive estimate of productivity is needed, large quantities of data are available, and the comparability of cohorts is established, a simple count of publications may well provide adequate information. Ordinarily, however, such a single measure is useful primarily as a means of setting the stage for a more comprehensive investigation of some aspect of science or scientific behavior.

**Weighted Counts:** The use of weighted counts of papers permits obtaining a preliminary estimate of quality without waiting for citations to become available; it is also an inexpensive means of obtaining an estimate of quality for large numbers of papers.

Each paper is weighted by an influence weight assigned to the journal in which the paper appears.[1]

**Paper Counts in the "Best" Journals:** Committees charged with evaluating group or individual scientific performance will sometimes request that publications be counted only in a selection of the "best" journals. Such a practice would be seriously inequitable, since scientists do not have equal access to journals. For example, those located in smaller institutions are more often published in less influential journals, as are younger, less well-established investigators; and regional differences abound in some disciplines. McAllister and Narin (1983) investigated these relationships in the publications of all U.S. medical schools, using average citation influence per paper measures: the average citation influence per paper increased with the total number of biomedical publications, even when institutional control (public and private), region, and areas of research emphasis were controlled. The positive relation between number of papers and citation influence was shown to hold within disciplines (biochemistry and internal medicine were analyzed in detail) and within research "level" (i.e., along basic and clinical research dimensions).

**Data Bases:** NIH-supported studies that have involved counts of published scientific papers have almost always depended on computerized data bases derived by CHI from Medline and the SCI. The source data bases require a great deal of preliminary massaging to consolidate information and correct inconsistencies; but once prepared, they make data available unobtrusively, make accessible several different quantitative measures of publication performance, avoid the increasingly restrictive problem of securing clearance from the Office of Management and Budget (involved, in studies of federal programs, in any attempt to go directly to the scientific community for information), and are more accurate than individual reports. An interesting departure from the use exclusively of the comprehensive data base was reported by V. L. Simeon et al. (1986), who had studied a large research institution in Yugoslavia. In their study several forms of publication and communication were employed in addition to SCI journals (e.g., papers in other scientific journals and congress proceedings, books and monographs, technical articles in encyclopediae and popularizations, and presentations at scientific meetings). A multivariate analysis revealed interesting patterns of change among the several variables over time. This rather preliminary study, which was focused on change in publication behavior following the introduction of minimal criteria for promotion warranted no conclusions; but it suggested to this writer the possibility that some measures of these types might be useful in considering criteria suitable for assessing the productivity of individuals whose careers, though academic, are not directly focused on the production of original research.

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[1] The technique developed by Computer Horizons, Inc. (CHI), determines journal influence weights by the weighted number of citations each journal receives over a given period of time. See F. Narin, *Evaluative Bibliometrics: The Use of Publication and Citation Analysis in the Evaluation of Scientific Activity* (Report to the National Science Foundation), 1976; and F. Narin, G. Pinski, and H. H. Gee, "Structure of the Biomedical Literature," *Journal of the American Society for Information Science* 27:25-45, 1976.

**Activity Indexes:** In recent years the utility of a new approach to using publication counts, the "activity index," has been demonstrated, particularly in studies conducted by CHI for NIH. Activity indexes are ratios that make use of publication counts in a relational context, thus allowing comparisons to be made among groups while allowing each group to be described within its own context.[2] Describing NIH Institutes' relative investment in the support of research in different disciplines is a case in point (see Gee and Narin, 1986). Journal papers are more readily and accurately assigned to disciplines than are dollars, and a ratio that describes an Institute's investment in a discipline relative to both the Institute's investment in all disciplines and the "size" of the discipline among all others in a data set provides a great deal of information for comparison among both disciplines and Institutes. Schubert and Braun (1986) suggest several additional types of indexes that might be useful for different purposes.

## CITATIONS

Ever since Clark's study of psychologists (1957), citation counts have been a favored measure for the assessment of productivity. In most cases, citations alone or in combination with publication counts are more closely correlated with subjective estimates of productivity than are any other measures. They are more universally applicable to the assessment of scientific research activity than are other measures because (1) publication is the most accessible means of expression available to all scientists, and (2) being published offers a broader audience to the scientist than any other medium.

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[2] The percent of an organization's papers that are published in a given discipline is divided by the percent of all papers in the data set that represent that discipline. An index of "1.0" indicates that the level of publication activity of this group in this discipline is consonant with the level that discipline represents among all disciplines.

Rather than referring to citations as measures of "quality," as was common in the 1970s, the current practice is to refer to them as measures of "impact" or "utilization" or "influence." The implication is that before citations can be referred to as measures of the "quality" of research, the issue should be investigated in the given context of definition.

From an entirely different perspective, Moravcsik (1986), Chubin (1987), Cronin (1984), Vinkler (1987), and others have discussed and/or analyzed the functions and meaning of citations in terms of author motivation. Vinkler, whose contribution is most recent, has provided a concise review of the literature concerning definitions, classification, and roles that citations play in the scientific literature, concluding (in concert with Cronin) that the information carrier role is the most important. Vinkler distinguishes between "professional" (work is based on the cited work or uses part of it) and "connectional" (e.g., desire of an author to establish a connection with the cited author or work) reasons for citation. In Vinkler's study, a group of productive investigators rated each of the references they had listed in a selected recent paper, identifying which of eight professional and/or nine connectional reasons had motivated the decision to cite, and the strength of the motive. Most (81 percent) citations were made solely for professional reasons--that is, in a literature review for "completeness" or because the current work was based at least in part on the cited work, the cited work confirms or supports the work in the citing paper, or the cited work is criticized or refuted (at one of three levels). Citations made partially for professional and partially for connectional reasons accounted for 17 percent; only two percent were made solely for connectional reasons. It was also found that two to three times as many papers are reviewed as are actually cited. Failure to cite was also investigated; the principal reason found was that a work was not considered important enough to the current effort to warrant citation. Second most important was the "obliteration" phenomenon--the origin so well known that citation was not needed. A citation threshold model has been developed, and data confirm that the threshold depends primarily on the professional relevance of the work potentially citable in a given paper.

Narin (1976), considered citations as an assessment mechanism:

> Citation counts may be used directly as a measure of the utilization or influence of a single publication or of all the publications of an individual, a grant, contract, department, university, funding agency or country. Citation counts may be used to link individuals, institutions, and programs, since they show how one publication relates to another. . . In addition to these evaluative uses, citations also have

> important bibliometric uses, since the references from one paper to another define the structure of the scientific literature.

Narin has presented both literature reviews and extensive analytical evidence that substantiate the utility of citations in the assessment of productivity and provide a most valuable guide to technical aspects of their use (e.g., with respect to the consideration of such issues as time, differences among fields and disciplines, and the use of indexes to make possible cohort comparisons).

In 1982 Narin and McAllister prepared for NSF a complete set of counts of all U.S. papers listed in the SCI for the years 1973 through 1976 and distributions of the citation counts received in the first through the fourth years after publication (mean, median, and mode) by each of the 106 subfields listed in NSF's *Science Indicators*. The average (mean) number of citations received in the first four years by papers in biomedical subfields ranged from 1.8 for "Miscellaneous Clinical Medicine" papers to 15 for "Biochemistry and Molecular Biology" and "General Biomedical Research" (publications in journals such as *Nature, Science, Federation Proceedings)*. The data illustrate dramatically the importance of taking disciplinary differences into account.

As with publication counts, the day has long since passed that simple citation counts would be regarded as acceptable measures of performance. Even average numbers of citations per paper are useful measures only when all of the precautions cited for paper counts are observed--that is, controls are exercised for sources of difference, such as discipline and time (both publication date and citation count period), that are not part of the question addressed. A longitudinal study of NIH-supported research 1973-1980 (Gee and Narin, 1986) employed citation counts per paper that had been scaled in relation to time and transformed into a standardized score in relation to all papers in a given research level, field and subfield. In a more recent study, Gee (1988) employed counts of papers in which each paper was weighted by the "influence weight" of the journal in which it appeared. For early examples of carefully considered treatment of citation data, see Carter's 1974 and 1978 reports on the NIH Peer Review system and on comparison of program project with individual (RO-1) grants.

**Highly Cited Papers:** The percentage of papers produced by a cohort whose members' papers are among the most highly cited 1, 5, or 10 percent of all papers in a discipline or specialty has particular appeal as an assessment of quality. With a computer the data are easily obtained, and the technique admits the inclusion of an outstanding paper that has been published in a less touted journal, is not directly influenced by author institution, is free of the possible biases of peer ratings, and provides an appropriate means of comparing across many different group dimensions. It is disadvantageous only for the cohort so large that it virtually defines the distribution of citations received by a group of journals. (For example, papers supported by the National Cancer Institute and the citations that they receive virtually define the distribution of citations to "cancer" journals). Comparisons between citation averages and percent of papers among the most highly cited 10 percent offer added insight into the distribution of performance within individual cohorts.

Although the overwhelming majority of studies that have compared subjective ratings with citation counts have yielded strong positive correlations, not all have. Where the correspondence is weak, the data often serve to reveal characteristics of the peer judgments rather than indicating deficiency in the citation evidence (see, for example, Anderson et al., 1978).

## JOURNALS AND SUBFIELDS

Some of the dimensions of difference among journals and subfields are described in Narin (1976): using the 1973 SCI, tables were developed showing the distributions of differences in types of publications (articles, notes, letters, etc.), numbers of journals, publications, references, citations, and ratios of these counts. Dimensions of differences drawn from these tables include the following:

- Discipline (or subfield) differences in numbers of references, citations and publications: In the 1973 SCI (articles, notes and reviews), citations per paper ranged from 2.4 for operations research and management science to 36.2 for physiology. In general, there are distinctive differences among fields and subfields: for example, mathematical scientists use few references, receive small numbers of citations, and produce relatively few papers while many basic biomedical scientists publish frequently and receive large numbers of citations.
- Variation in rates of growth and time distributions of citations: Rapidly growing subfields of science have higher fractions of references to recent papers than do slow-growing subfields. Rapidly growing subfields also tend to receive their modal numbers of citations earlier than do other subfields (e.g., in the second, instead of third, year after publication).

- Concentration and relative citedness: The concentration of publications and relative citedness varies both within and between fields of science. Some fields are characterized by relatively few, very large and influential journals while the literature of others is widely dispersed.

This kind of information was not widely discussed in the open literature until Moed et al. (1985) at the University of Leiden published their investigations that demonstrated the serious impact, especially on analyses or assessments within universities, of neglecting these characteristic differences among disciplines. The Moed study also revealed that operating on incomplete bibliometric data can have a serious impact on the outcome of an assessment. The characteristic differences among fields, subfields, and specialties of science have led to the development of a growing number of indexes that are aimed at making comparisons between cohorts justifiable. The most widely used are impact factors, influence measures, and relative citation rate and publication impact:

**Impact Factors**: The Institute for Scientific Information, publisher of the *Science Citation Index*, also publishes *Journal Impact Factors*, based on a 2-year accumulation of citations received divided by the number of papers published in the target year. These measures, while correcting for journal size, do not correct for characteristic differences in referencing and citation practice and, therefore, reflect different dimensions of citation behavior in different disciplines. Noma (1986) states:

> . . . there is no normalization for the different referencing characteristics of different segments of the literature: a citation received by a biochemistry journal, in a field noted for its large numbers of references and short citation times, may be quite different in value from a citation in astronomy, where the overall citation density is much lower and the citation time lag much longer. In addition, journals that publish longer papers, such as review journals, tend to have the highest impact factors.

Schubert and Glanzel (1983) have developed a method of estimating the reliability of mean citation rates per publication, computing a standard error based on the relative frequency of zero citations. They exemplify its use by computing a sample set of "corrected" ISI impact factors. They are, however, still left with the lack of comparability in other aspects of differences among disciplines.

**Influence Measures**: Pinski (1975), Anderson et al. (1978), and Noma (1986) developed three citation-based journal influence measures that offer greater breadth and precision of measurement than does the impact factor for capturing the information resident in the journals in which research is published. The three measures are:

- Influence weight, which is a size-independent measure of the weighted number of citations a journal received from other journals, normalized by the referencing practices of the field
- Influence per paper, which is essentially the weighted number of times an average paper in a journal is cited, where the weight is based on the influence of the citing journal; and
- Total influence (of a journal), which is the influence per publication times the total number of papers published over a given period of time.

Of these three measures, the influence per paper measure has proved most useful in studies of group publication performance. Total influence scores are, however, the scores most highly correlated with subjective judgmental ratings of university program quality (see Anderson et al., 1978). The influence measures offer a clear advantage over impact factors: the measures are determined within each of the fields of science, thus correcting for differences in citation practices and providing comparability across fields of science. In addition, citations from prestigious journals are weighted more than those from peripheral journals, thus introducing a quality concept, and the three different measures provide information from three different perspectives. Despite their superiority, influence measures have not been widely adopted. The iterative matrix manipulations involved are costly and cumbersome; as a result, it is not economical to revise them frequently, and only one revision--using 1982 publications--has been made of the original measures based on 1973 publications (see Noma, 1986). The number of journals in the 1982 set increased to over 3,000 from the 2,300 on which the 1973 measures were based. Changes in computational techniques were also made, so average measures are not directly comparable. Even so, Narin (1985) reports, that most correlations within fields ranged between r = .85 and r = .95; highly influential journals retained their high influence, and journals with relatively low influence ratings (e.g., r = .40 to .60), tended to drift within that range. Depending, of course, on the aims of a study, it would appear that in many cases comparability of measures among disciplines should take precedence over recency of citation count.

**Relative Citation Rate and Publication Impact**: Schubert et al. (1983, 1986) and Vinkler (1986) have proposed two new "relative" citation indicators based on Garfield's SCI journal impact factors. Schubert's "relative citation rate" (RCR) compares actual citation counts with an expected citation rate based on the impact factors of the journals in which a set of papers has appeared, thus eliminating characteristic differences in the publication and citation practices among disciplines. Schubert and Braun (1986) and Schubert, Glanzel, and Braun (1983) have used these indicators in developing relational charts on which the relative merit of nations' publications are compared.

Vinkler developed a "relative publication impact" ($P_I$) measure--which includes with a relative citedness indicator, numbers of publications and a "cooperation" measure based on coauthorships--to arrive at an index that includes both quantity and quality in its ratings (of departments, in this instance). Vinkler reports "good agreement" with subjective peer evaluations that are carried out regularly. None of these measures have yet been subject to critical review, nor have they been used outside the context in which they were developed. Further exploration does appear to be warranted.

## PEER ASSESSMENT

Peer assessment, as the concept was developed by NIH to overcome the potential biases of individuals in decisionmaking situations, is now in the anomalous circumstance of being defended against intrusion by some biased individuals who oppose statistically based measurement techniques while at the same time being attacked by apparently politically motivated individuals who accuse peer assessment in the management of science of the very biases it was designed to overcome. Compounding the anomaly is the fact that the defenders fail or refuse to recognize that the quantitative analysis "intrusion" that they reject can and has provided, by far, the most convincing evidence available to prove the case for peer review. Longitudinal studies of NIH-supported publications (see Gee and Narin, 1986), for example, are unequivocal in their demonstration of the effectiveness of the NIH dual peer-review system of determining which grants shall be funded.

It is also something of an anomaly that we treat peer assessment as one among several different types of criteria that might be used to assess productivity, when in fact, almost all likely criteria are, at bottom, different representations of peer judgment. For the most part the different measures represent collections of judgments that are separated in time, in focus, and in method of combination. When a peer group is assembled to assess the productivity of an individual, a group, or a program, the outcome is based on the combined perceptions of any assortment of behaviors or perspectives its individual members may implicitly or explicitly agree upon at the time the judgment is delivered. Other measures, such as those derived from counts of citations to an accumulation of publications, represent a long series of separate peer and peer-group assessments ranging from acceptance to college and graduate schools, through awards of degrees, positions, funding, selection for publication and decisions to cite. The difference is that each of these assessments has been specifically focused on a related concept of merit, and the outcome statistics derive from the judgment of many more and more disparate peers. There is no question of which is the "better" type of measure; they represent different perspectives--sometimes only slightly and sometimes widely different. The quality and utility of either depends on the care taken to secure accuracy and to eliminate inappropriate or unfair considerations from the outcome and on the context in which the results are used. The significant point is not the superiority of one or the other measure but, rather, the extent to which either or both illuminate the questions at hand.

Those who are concerned with achieving a better understanding of how science functions seldom argue the point that peer review groups that can take into consideration not only an immediate product or situation, but also any extenuating circumstances that might alter the significance of any given piece of information are, as yet, better equipped to take into account all relevant factors in making a judgment about, for example, an individual grant application than any likely collection of statistics. (This is not to say that there do not exist experimental techniques that might well improve peer judgment procedures. It ignores also the issues of personal and group bias, which may seriously distort judgment). When very large groups of individuals or products--such as programs or large sets of publications or whole journals--are at issue, however, and combinations of statistical measures correspond imperfectly with peer judgments, it may now, after three decades of very active research, be prudent to conclude that here are two different kinds of evidence, each of which potentially offers useful and valuable information, and each of which should figure in the assessment process (assuming, of course, equally careful data gathering and handling).

**Citations and Peer Assessment:** Most studies that have involved both peer judgment and bibliometrics have been aimed at validating the utility of the bibliometric measures. The wellspring Clark study (1957), however, which was conducted before the analysis of publications became an object of social scientific interest, simply noted that the multivariate combination of journal citations and offices held in a professional association together accounted for nearly 64 percent of the variance in numbers of votes received when active investigators were asked to identify significant contributors to the field. The single most important predictor was citations, which correlated $r = .67$ with the number of votes.

Carter's report (1974) was the first serious analytical investigation of the NIH research grant peer review process. Publication and citation data, dating from the late 1960s, were inadequate by present-day standards, but the kinds of considerations Carter brought to the problem still warrant the attention of anyone proposing to investigate these kinds of relations. Carter found a low correlation (r = .40) between initial and renewal priority scores, and that

> . . . at least for grant applications from most of the larger basic science and clinical departments of medical schools, the judgments of the peer review process are significantly related to an objective measure of research output derived from citations to articles describing the results of the grant.

Two reports issued by the National Academy of Sciences in 1982 represent nearly opposite perspectives on the use of peer judgment and objective measures in assessment. One, in which opinions but no data or objective evidence of any kind were presented, concluded, essentially, that peer review was the only mechanism needed to assess quality or productivity in scientific research (COSEPUP, 1982). The other, in sharply contrasting peer group performance, applied 16 "measures"--4 based on peer ratings and 12 on records of program composition, support, and faculty publication performance--applied to 32 disciplines in 200 doctoral degree-granting institutions.[3] In the four biological science areas of primary concern to biomedical research, total journal influence ratings of faculty publications accounted for 50-70 percent of the variation in subjective judgmental ratings of faculty scholarly quality and 40-60 percent of program educational effectiveness. Notably, no attempt was made to combine the different types of information; rather, each of the items was reported for each institution.

A recent analysis by Lawani and Bayer (1986) of relations between peer and bibliometric assessment of quality is of interest because it compared peer and bibliometric assessments of cancer research papers. Papers abstracted in the *Yearbook of Cancer*, a selection made by large numbers of "peers," were classified as of high quality and compared with (1) papers listed but not abstracted and (2) a restricted random sample of papers listed in *Biological Abstracts*. While citation frequency increased significantly with peer rating, there were discrepancies in the distributions. Of the most highly cited 100 papers, 14 were from the random set; also, 16.8 percent of the highly rated papers received 4 or less citations in the five years following publication (2.3 percent received none). Whether some of these will turn out to be "late bloomers" or will represent poor or biased choices for inclusion in the yearbook abstracts is not known. Lawani also found that quantity and quality were highly correlated and that the larger the number of coauthors, the larger the proportion of papers included in the yearbook. Also, self-citations relative to total cites declined with increased quality but did not affect the level of agreement between peer assessment and citation count.

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[3] The Committee on an Assessment of Quality-Related Characteristics of Research-Doctorate Programs in the United States began its work in response to growing criticism within the academic and educational communities of existing subjective ratings of graduate programs in the United States. The reports of this study serve as models of planning and reporting in the development and application of program assessment methods. Evidence is presented at every stage of development of the study to support decisions and analytic methods.

Porter, Chubin and Xiao-Yin-Jin (1986) recently compared Sloan Fellows' "most cited" papers with their own selection of which of their papers were their "best." For 1974 fellows, 35 percent of papers they perceived as "best" were also most highly cited; this percentage rose to 42 for 1984 fellows. Eighty-nine percent of papers were coauthored, but Fellows were much more likely than citations were to select as best those on which they were first author. The letters that had recommended the Fellows for appointment, and the citations to their publications tended to emphasize methodological contributions; fellows themselves tended to identify their theoretical and empirical papers as their best.

Research evidence suggests that, when possible, both peer and bibliometric data should be made available for consideration. If only one measure can be obtained, in any study involving large numbers of subjects and publications (e.g., >100 papers per subgroup), the investigator would be at least as well served with publication data as with peer judgments.

## GRANTS AND GRANT APPLICATIONS

NIH and the Veterans' Administration are probably the only two federally supported agencies that maintain data bases suitable for the analyses of scientist's grant application and award behavior. It has been possible in recent years to obtain some information about individuals to whom the National Science Foundation and several private foundations have awarded funds, but no information about applications has been available. The availability of accurate and complete information about grant applications and awards makes possible the investigation of many management and policy issues. Clearly also, the receipt of an award is itself an indicator of achievement, especially in recent years when only small percentages of grants are actually awarded.

The availability of longitudinal data on those who have become involved with NIH programs is unique.

As sources of information about NIH programs and policies, the grant information, in conjunction with the publication data available in NIH data bases, constitutes a treasury of resources for the social and cognitive study of science that is probably unmatched elsewhere in the world. It is therefore extremely unfortunate that little or no opportunity exists for exploiting these resources in the interest of further developing the theory and methodology needed to advance our understanding of how science functions.

One of the least valuable ends to which grant information can be put is as a single measure of the effectiveness of training support programs. The positive information that is yielded is, of course, directly informative, but when applications and approvals are compared with awards (with no control for disciplines or for type or location of appointment), the results can be misleading. Failure to apply for grants has been interpreted as a negative outcome, whereas non-application may be totally irrelevant to the productivity of both individuals who are pursuing research and those who are performing other services to science that can be regarded as successful. Some creative new attempts may be in order to design studies that will permit alternate patterns of successful outcome for such individuals as those engaged in research that is otherwise supported, as well as those whose administrative or teaching responsibilities preclude their applying for grants. This is not to say that grant applications and awards are not an important source of information about, for example, the success of training programs. It only cautions against its use exclusively, and without consideration of such limitations as disciplinary differences and the availability of funding.

## ACADEMIC RANK, RATE OF ADVANCEMENT, SALARY

These three measures are possible alternative measures of one aspect of advancement or productivity for individuals in different settings or with different types of appointments. Each must usually be qualified in terms of years since doctorate or since completion of training, and it should be possible to scale each of them so that comparability among individual members of a cohort would be achievable. Data about rank and rate of advancement are generally more readily available than salary information: private universities often refuse to release salary information, but will yield rank; industry, on the other hand, which often balks at releasing information about its investment in research and development, is usually less unwilling to report the salary of an individual employee. Problems with these measures are likely to be related to institutional size, policy, and prestige and caution is obviously needed to assure comparability. Even when all of these are taken into account, it is possible that constraints on salaries and promotions in different institutions may be such that the measures would be of marginal value.

## HONORS AND AWARDS

It is intuitively desirable to be able to give "credit" for having won honors or awards. While information about them is generally available from the individuals who have received them, access to the individuals is rarely available in connection with federally supported studies because of the continuing effort of the Office of Management and Budget to restrict data gathering. As a result, obtaining the information is often a tedious exercise; and with the hundreds of different awards made among all of the sciences, the chances of missing some are not small. However, biographical sources carry this kind of information, and the awarding organizations are also receptive to inquiry.

The principal problems with awards and honors are the inequalities of opportunity and of significance to which they are prone. Again discipline is important, for access to awards varies widely among them. Location of employment may also militate against the opportunity to gain recognition, and the related gains of prestige and cumulative advantage. Some rather ingenious efforts have been made to overcome some of the disadvantages of these measures: The Coles (1973) had 300 physicists rate the visibility and prestige of 98 honorific awards and used their ratings to weight the available information. Others have set a mark--that is, some number of awards or honors may be set as a level of "success." As with grants, receiving awards may be a suitable indicator of achievement, but awards are very rare, and not receiving them is not an equitable indicator of their absence.

## MENTORING

Mentoring has usually been studied as a predictor of the subsequent success of students (see, for example, Long et al., 1979), but as a measure of productivity it has generally been rejected because popularity as a mentor has been associated with the concept of operating "diploma mills." If suitable means of assessing the performance of individuals whose principal activities do not include active research participation or who devote only a small proportion of time to research are to be found, mentoring should be reconsidered. The mentor whose students become outstanding achievers may or may not deserve credit for having made an important contribution to science. Only studies that are able to obtain accurate assessments of ability, and to consider very long time spans are likely to be able to deal with such a measure (after completion of training and appointment to a university, it would probably require about 15 years' followup to obtain a minimum amount of useful information). An alternate measure to be considered could be assessment of a mentor's success in placing students on completion of the doctorate. If such a measure could be partialed out from its inevitable association with prestige of the mentor's institution, it should prove to be an appropriate measure. Placements could be "scored" by referring to the National Academy of Sciences *Assessment of Research Doctorate Programs* (Jones et al., 1982) for the appropriate disciplines.

## PATENTS

While it can be assumed that any participant in the scientific community is willing, if not eager, to receive an award, the pursuit of patents is a specialized goal of a restricted subgroup. With the easing of federal restrictions on the ownership of patents, interest in obtaining them has undoubtedly increased in the population of scientists that was formerly restricted. To what extent the changing mores of society, which strongly encourage the deliberate pursuit of material reward, may also affect scientists' problem-selection behavior is not, to this writer's knowledge, known. But the current "state of the science" of many areas of research in the biomedical sciences, which has produced rapidly expanding opportunities for producing scientific advances that have significant commercial potential, is surely not without effect. Among scientists employed in the commercial sector, patents and salary are probably the two best potential measures of productivity available. But how patents should be assessed in the academic sector is not so clear, and whether academics will change their publication behavior when nearing a patentable advance, as many in the commercial sector have been forced to do, is also not clear.

Patents have become an international focus of attention in assessing the productivity of nations. Narin's report to NSF (1988) of comparisons between U.S. and Japanese patent activity has drawn widespread journalistic as well as scientific interest. Together with several present and former staff members, Narin has established a new dimension in bibliometrics through studies of relations between publications and patents. CHI, of which Narin is president, has developed a "Patent Citation Indicators Database" and "Full Text Patent Citation Data." The first makes available all information on the first pages of close to a million U.S. patents issued since 1971; and the second provides extracts from the full texts of patents issued between 1975 and 1983, including citations to U.S. and foreign patents. These resources are as yet untapped for studies of NIH research programs, although the potential for investigation of a wide variety of questions at the interface between science and technology is great (see, e.g., Noma (1986).

Keith Pavitt, a member of the prolific science studies group at the University of Sussex, has prepared an excellent review (1985). He notes early work in the 1960s, increased interest reflected in NSF's *Science Indicators*, and lists sources of data in Western Europe and the United States. The state of the field is discussed under the following headings:

- analytical approaches (Narin, various economists, and NSF's *Science Indicators*);
- types of activity measured (invention as distinct from innovation, relation to R&D expenditures, relative superior performance of small firms, protection against imitation, skewed distribution of monetary value);
- international comparisons (summaries of several empirical studies in such areas as relations between per capita capitol expenditures on R&D and patent activity, problems of data-gathering in foreign countries, national differences in propensity to patent);
- comparisons among industrial sectors (technology gap theory, difficulties of allocating patent classes uniquely to product based industry classes, relation of this problem to accuracy of estimates in different fields);
- comparisons among technical fields (classification problems in attempting to relate patenting to rates of technical innovation, citation rates of "significant" patents, links between patents and scientific literature, technical profiles of industrial firms);
- comparisons among industrial firms (relations between R&D and patenting, skewed distribution of value of patents and propensity to patent, inverse relation between propensity to patent and size of R&D programs); and
- comparisons over time (increasing share of U.S. patents that are of foreign origin, possibility of increased concentration in relation to diminishing ratio of patents to R&D size).

Pavitt concludes with a list of areas in which systematic inquiry is needed. He contends that the elimination of sector and firm-specific biases will require more comprehensive and accurate information about the nature and determinants of patenting behavior within firms. Systematic sample survey data are required on the following subjects:

- the sources of the innovative activities that lead to patenting in particular, the intersectoral variance in the relative importance of R&D, production engineering small firms, and other sources;

- the time distribution of patenting activities over the life cycle of an innovation (in particular, does patenting typically reach a maximum at the time of commercial launch?);

- the propensity to patent the results of innovative activities: in particular, sector specific factors related to the effectiveness of patenting as a barrier to imitation, compared to alternatives; firm-specific factors related to perceptions of the costs and benefits of patenting; and country-specific factors relating to the costs and benefits of patenting; and

- the judgment of technological peers on the innovative performance of specific firms and countries, and on the relative rate of technological advance in specific fields: in particular, the degree to which these judgments are consistent with the patterns shown by patent statistics.

Finally, Pavitt calls for improved classification schemes, such that established patent classes can be matched more effectively, on the one hand to standard industrial and trade classifications and, on the other, to technically coherent fields of development.

## SUMMARY

There are, simply, no easy, ready-made solutions to the problems of identifying measures that will be useful in the assessment of productivity. There is need for the development and application of creative approaches to improving the utility of the kinds of information that can be obtained. The development, for example, of indexes that may increase the equitability of some measures. And there is need as well, in many cases, for increased attention to detail in designing studies and analyzing data.

The two sources of information that have the broadest potential value in the assessment of academic scientific performance are peer assessment and the analysis of publications, though there are circumstances in which neither may be appropriate. (For analyses involving the commercial sector, patent analysis--when used as an extension of publication analysis--should probably be added.) From the perspective that they tend to be fairly highly correlated, each contributes somewhat to confidence in the other, and to the extent that they are not correlated the need for both kinds of information is greater in the given measurement situation. Because peer assessment is so extremely costly, time consuming, and difficult to employ equitably, it may be necessary or worthwhile, especially in large-scale studies, to investigate whether there are records available about--for example, program operation, faculty activity, support, student outcomes, and resources (in addition to publication data)--that might be able to account for a large proportion of the variation in peer judgments of, program quality.

On the other hand, the use of publication and citation measures as the sole consideration in the assessment of the individual scientist's productivity can be rejected on a purely rational basis. As a means of confirming a positive subjective judgment of individual performance, there is no problem, but the opposite does not hold because there are myriad alternative explanations for low numbers of publications and for few or no citations. One of the more significant misjudgments that can result is the case in which few or no citations are received by highly significant papers that either are ahead of their time or are published in obscure journals. No imperfect tool that may be used to the disadvantage of the single individual (including peer judgment) can be justified. The caution warrants repeating (and appears fairly frequently in the bibliometric literature) that bibliometric measures are most appropriately employed in group comparisons in which aggregates of publications are large--just how large depends on how closely comparison groups can be matched. Correspondingly, peer assessments are most appropriately employed when peers are equally informed about all of the assessment targets and when self-serving competitive interests are absent. Perhaps the single most important factor in planning investigations of productivity is the need to employ multiple measures and to apply them selectively to the appropriate targets.

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# APPENDIX: SCIENCE STUDIES RESOURCES

Nearly three-quarters of a century has passed since Cole and Eales in 1917 reported their international comparison of counts of books and papers in comparative anatomy published between 1543 and 1880 (Narin, 1977). In 1926 Lotka demonstrated that the distributions of publications in a discipline (physics) is widely skewed and that most scientific papers are published by a small minority of scientists (Fox, 1983). So began inquiries into the use of publications measures in the assessment of productivity and the closely related concept of eminence. Rapid advancement, however, became feasible only when computers became readily accessible and inexpensive in the 1950s.

In a landmark empirical study conducted between 1954 and 1957, a committee of the American Psychological Association conducted an extensive inquiry into the correlates of productivity of all doctorates granted in the field of psychology between 1930 and 1944 (Clark, 1957). The study was significant in employing publication and citation measures as correlates of peer assessments of productivity and in recognizing the importance of investigating differences among subdisciplines and of taking into account variations in background, social, and psychological characteristics as correlates and potential predictors of eventual professional accomplishment and status. The study was also noteworthy in its use of computer-implemented quantitative methods to describe and compare the most productive with other members of the profession. In this sense it marks the empirical beginning of what has become a worldwide effort on the part of both theoretical and empirical investigators to achieve a better understanding of how science and scientists function and thrive in the society of our time.

Comprehensive theoretical and methodological as well as empirical studies of the sociology, psychology, and economics of science and scientists did not begin to appear in large numbers until the 1960s. Derek de Solla Price (1963) is appropriately credited with sparking the present-day intellectual development of inquiry into the assessment of research quality and eminence. Since then studies have proliferated rapidly in depth, breadth, and complexity as well as in number. Hjerppe (1982) added 518 items to an over 2,000-item "Bibliography of Bibliometrics and Citation Indexing & Analysis" published in Sweden in 1980. More directly relevant to the present inquiry are bibliographies that are being developed to assist groups of interested and involved scientists in their attempts to keep up with research aimed at achieving better understanding of how science and scientists function. Although it is not feasible to attempt a comprehensive review of all bibliographies that might be helpful to those concerned with the analysis of productivity and its essential correlates, a brief description of some publications that cover a great deal of the relevant research effort to about 1980 may be useful.

*** Jonathan and Stephen Cole, *Social Stratification in Science* (1973): The Coles conducted several different cross-sectional studies of academic physicists in their investigation of the social stratification system in science. The Coles staunchly defended the view that science functions as a meritocracy and concluded that physics is a universalistic and rational discipline in which quality of work (as measured by citations) is the chief determinant of ultimate status. (A recent personal communication indicates that J. Cole delivered a paper at American Sociological Association meetings that partially recants earlier views on universalism.) For more up-to-date, longitudinal analyses of scientists in biochemistry that result in a different conclusion, see Long et al. (1979), Long and McGinnis (1981), and McGinnis and Long (1982). The Coles examined multivariate interrelationships among departmental rank, number and assessed prestige of honorific awards, membership status in professional societies, geographical location, number and "quality" (citation counts) of publications in exploring the development of professional visibility, and eminence. The book also contains a brief historical account of the development of research in the social science of science.

*** Francis Narin, *Evaluative Bibliometrics* (1976): Narin cited 140 papers in providing a brief historical account of the development of techniques of measuring publications and citations, in reviewing a number of empirical investigations of the validity of bibliometric analyses, and in presenting details of the characteristics of and differences among scientific fields and subdisciplines. (The Annual Review of Information Science and Technology published a bibliography entitled "Bibliometrics" by Narin and Moll (1977), which contains many, but not all of the same references that are in *Evaluative Bibliometrics*.) The book, prepared for the National Science Foundation, contains explicit details of how several indices of journal influence are calculated and how variations within a field of science differ from variations within a subdiscipline. Three different influence measures are provided for each of the 2,250 journals in the 1973 *Science Citation Index*. [(New influence indices have since been calculated for some 3000 journals in the 1982 SCI (see Noma, 1986).] Some two dozen studies are cited that deal with the correspondence between literature-based and other methods of assessing the quality of scientific output.

*** NSF Division of Planning and Policy, *Social Studies of Scientific Disciplines*, (1982): This annotated bibliography "makes accessible to the managers and practitioners of science and engineering the findings from the social studies of science in a form that will be useful to them." The bibliography covers studies conducted up to the mid 1980s and reports on the work of nearly 300 authors, most with multiple entries. Although only one subsection is entitled "Productivity," it is not an exaggeration to estimate that at least 90 percent of entries in the work deal with material relevant to the measurement of this concept. An approximately similar percentage describe investigations that employ publications measures in their investigations of 23 identifiable but related subjects as dealt with in studies of 13 disciplines. A total of 285 studies yield nearly 500 entries in the bibliography, many studies having dealt with multiple disciplines. Subject categories in the bibliography include:

- Attitudes and Values
- Career Patterns
- Competition
- Development of Disciplines
- Discipline Comparisons
- Discipline Organization
- Discovery Process
- Education, Grad. Educ.
- Funding of Research
- Information Exchange
- National Comparisons
- Paradigm Characteristics
- Performance of research
- Productivity
    - Productivity - age
    - Professional Associations
- Publication practices
- Recognition and reward
- Social stratification
- Structure of the literature
- Structure of literature--
    - Specialty groups
    - Citation rates
    - Journal influence
- University Ratings

*** Mary Frank Fox, "Scientists' Publication Productivity," *Social Studies of Science* (1983): In this critical review, Fox discusses publication productivity in relation to psychological characteristics of individuals such as motivation, ego strength, cognitive style, personality and interests, and IQ, noting the restricted range of ability among scientists and the corresponding low correlation with measures of productivity as well as the fact that creativity does not exist in a vacuum. Citing Pelz and Andrews, she states, "Rather, social factors so affect the translation of creative ability into innovative performance that measured creativity is virtually unrelated to either the innovativeness or the productiveness of scientists' output." The importance of environmental characteristics such as institutional prestige and organizational freedom are summarized, including the important findings of Long and McGinnis, whose longitudinal studies point to the stronger effect of location on productivity than of productivity on subsequent location as had been previously reported in studies using cross-sectional designs. An interesting discussion of the closely entwined concepts of cumulative advantage and reinforcement is also included in this review of approximately a hundred different studies.

*** A. Schubert, "Quantitative Studies of Science: A Current Bibliography," *Scientometrics* (1985 and 1986). Close to 100 papers are listed in each year, and the list does not include those published in *Scientometrics* itself. The vast majority deal with empirical and methodological papers on bibliometric topics. While no country exceeds the United States in number of papers listed, the total number of foreign papers, not including Canada and the United Kingdom, was nearly twice the number of United States publications.

*** Robert C. Stowe, *An Annotated Bibliography of Publications Dealing with Qualitative and Quantitative Indicators of the Quality of Science (Including a bibliography on the access of women to participation in scientific research)* (1986). In addition to a list of core books, annotated entries are made under the following headings:

I. Bibliometric indicators of the quality of scientific research
  -Citations and publications as indicators of quality
  -Critiques of citation analysis
  -Citation Context Analysis
II. Qualitative approaches to and more general works on research evaluation
III. Works dealing specifically with "science indicators"
IV. Forecasting and research priorities
V. Peer review
VI. Quality and quantity in the history of science and philosophy
VII. Education
VIII. Issues involving quantity and quality in particular disciplines, including papers on social indicators
IX. Sociology of science
X. Methodological papers and bibliographies
XI. Access of women to participation in scientific research

# HEALTH SERVICES RESEARCH PERSONNEL: DEMAND, SUPPLY, AND ADEQUACY OF TRAINING RESOURCES

*Elizabeth McGlynn**

## INTRODUCTION

Health services research is an applied field that has as its domain all aspects of the health care delivery system. The ultimate goal of health services research is to provide the information base necessary to design a health care delivery system capable of maximizing the health of the population within the resource constraints imposed by the public and private sectors. The subjects of this research field include the training of health professionals; the process by which services are delivered; outcomes of care; methods by which patients pay and health professionals are reimbursed for care; the quality, efficacy, effectiveness, and appropriateness of services; and the interrelationships of these components.

Health services studies may be methodologic, descriptive, analytic, or experimental, which implies a range of requirements for trained personnel. The demands for individuals trained in health services research come from academe, government, and the private sector. Given the complexities of the health care delivery system, the field relies upon researchers trained in numerous disciplines, as well as those capable of bringing disciplines together to work cooperatively. Figure 1 illustrates broadly the domains of health services research.

| U.S. Population Health Needs --------> | Service Delivery System --------> | Outputs |
|---|---|---|
| --Demographics | --Efficacy | --Expenditures |
| --Culture | --Effectiveness | --Health transitions |
| --Morbidity | --Efficiency | --Satisfaction |
| --Mortality | --Equity | |
| | --Quality | |

FIGURE 1. A framework for health services research.

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* The opinions expressed in this paper are the author's and do not necessarily reflect those of either the Committee on Biomedical and Behavioral Research Personnel or the National Research Council.

Much of health services research looks at the relationship between the needs of the population and the delivery of services. The gaps between the demands for and supply of health technology often are studied in order to formulate approaches to closing the gaps.

Finally, health services research examines the output of the service delivery system as an indicator of system performance. The two outputs that have been the principal focus of research are expenditures on care and the health transitions (increments and decrements to health) that result from the application of service delivery system technologies. Others have argued that patient satisfaction with care also should be assessed. Economists, statisticians, and econometricians have developed tools for examining expenditures, whereas clinicians and psychologists have studied the health transitions and satisfaction.

The diversity of questions formulated and analyzed by health services researchers makes it difficult to develop a neat taxonomy of the field. In an effort to explain through example, the remainder of this paper describes the training of individuals engaged in health services research, the various pathways used to produce these researchers, the current levels of support for training, and future events that might affect the demand for health services research personnel. At the conclusion of the paper, the question of the adequacy of these mechanisms for producing enough well-trained health services researchers for the near term is discussed. Throughout, many questions are raised for which there are not adequate data to arrive at an answer. These questions are raised not to frustrate the reader but to suggest avenues for a more systematic inquiry into the demand for and supply of health services research personnel.

## WHO CONDUCTS HEALTH SERVICES RESEARCH?

Defining the requirements for health services research personnel is a complex task, for by its nature health services research is an interdisciplinary field requiring individuals trained in a variety of disciplines, as well as individuals who are capable of bringing disparate disciplines together to examine questions about the delivery of health services. Because there are no certification or licensing requirements, it is difficult to estimate the number and types of individuals who currently are conducting health services research studies. In this section four indicators of the types of individuals who constitute the health services research community are provided.

One indicator comes from the membership of the Association for Health Services Research (AHSR), the professional society for such personnel. Table 1 gives the distribution of AHSR's membership by discipline. As the table demonstrates, the membership includes a wide variety of disciplines; these have been categorized for presentation purposes into more aggregate groupings and originally included more than 40 named disciplines. The top three disciplines are medicine (18.1 percent), economics (13.2 percent), and public health (12.7 percent). No single discipline is dominant.

The educational background of the membership provides another illustration of the training received by those currently practicing in the field and is displayed in Table 2. About half of the members hold a research doctorate degree; about 21 percent are physicians or other health professionals; almost 20 percent have masters degrees; and the remainder have bachelors degrees, are in training, or did not specify their training in the membership survey.

The institutional affiliations of members illustrate the variety of professional settings in which health services research personnel operate. Table 3 provides a distribution of the membership by the institutional affiliation of the individual. The greatest proportion of members are located in university settings (46.5 percent), followed by health care delivery or private health industry organizations (almost 27 percent). Other private organizations (e.g., consulting firms) and government employees make up 10.8 and 5.2 percent, respectively, of the membership.

Finally, the publications that comprise health services research demonstrate the variety of topics considered and disciplines required to conduct such studies. The AHSR has an award each year for the best article in the field. Table 4 shows a listing of the titles, journals,(first author, and discipline of the articles thit were nominated for 1988 Article of the Year. Health services research is conducted by persons who have been trained in a variety of disciplines. Most of the studies are interdisciplinary in nature and require a team of individuals who can work together to solve the complex methodologic and conceptual issues posed by the subject matter. The articles shown in Table 4 provide one indicator of the variety and type of topics addressed by leading health services researchers and some sense of the disciplines involved. The extent to which the field is interdisciplinary is understated because only the first author is shown. Many of these projects included physicians, social scientists, and methodologists (e.g., statisticians).

## TRAINING FOR HEALTH SERVICES RESEARCH

As suggested from the above discussion, the training currently received by those who are conducting health services research covers a variety of disciplines and degrees; therefore, there are a variety of formal and informal ways in which individuals become trained. Thus, the discussion of training considers each of these approaches to training separately:

- disciplinary degree programs (e.g., programs that grant a professional or research degree in a traditional discipline such as economics);
- interdisciplinary training programs (e.g., public policy, health services research);
- postdoctoral training programs; and
- on-the-job training (e.g., socialization of research personnel into the field of health services research).

Because the scope of health services research is broad, most individuals probably are trained in a narrow aspect of the field and then receive socialization into broader issues through some combination of additional work (e.g., postdoctoral studies) or by learning on the job. Whether this is the most efficient means of producing such personnel remains an open question.

## DISCIPLINARY DEGREE PROGRAMS

Currently, most individuals engaged in health services research have received their training primarily from disciplinary degree programs, including economics, quantitative methods (e.g., statistics, operations research, epidemiology), sociology, psychology, management (e.g., business, accounting, planning), and so on. It seems likely that for the foreseeable future, the field of health services research will continue to draw upon individuals with disciplinary degrees for a majority of its personnel. Clearly, the degree requirements for these programs already are well established, and the principal issues for this group of potential researchers are as follows:

- the type and amount of training necessary to acquire health services research skills and
- the extent of migration between disciplinary and interdisciplinary research and methods for influencing migration.

Although health services research is interdisciplinary and depends upon the skills and knowledge of investigators who have received different training, as the field has become more mature, it has developed its own language and information base. For health services research to be conducted efficiently and effectively (i.e., to avoid reinventing the wheel), individuals who wish to engage in this research must be socialized into the field in some manner. The two most common mechanisms--

postdoctoral training and on-the-job training--are discussed below. Most formal training programs take about 2 years, whereas on-the-job training has a less specific time frame. The amount of time required probably depends upon an individual's prior training, experience, and aptitude for learning new applications.

One of the difficulties in estimating the number of persons currently engaged in or capable of performing health services research is that a majority of individuals have the potential of migrating in and out of the field. Further, some may spend only a portion of their professional time in health services research, while spending the remaining time in some other activity (e.g., medical practice or other disciplinary research). Migration may have the advantage of providing a nlexible work force capable of expanding and contracting to meet the demands of the marketplace. The impact of migration on the supply of personnel is an issue that is particularly relevant to interdisciplinary research. Because little is known about the effects of such labor-market patterns, an investigation of the role of migration on the demand and supply of health services researchers should include attention to the following questions:

- What is the minimum amount of time that must be spent in health services research in order to produce high-quality research?
- Is migration between health services and other research fields desirable?
- What are the implications of migration for the quality of research produced?

Having this potentially large source of human energy on which to draw for new health services research talent raises the question of the mechanisms by which such individuals might be attracted into the field. The attractiveness of any career path depends upon at least two factors: the financial viability of that avenue as compared to competing alternatives and the relative importance of the problems under study.

The funding for health services research is small relative to biomedical research; thus, among those who have biomedical research as an alternative, health services research probably is not as attractive. However, those who are competing for research funding in the behavioral sciences may find health services research relatively attractive. If research funding in this area expands, one might expect greater numbers of persons to be drawn into the field. Other mechanisms, such as Career Development Awards, that provide a stable source of funding for new entrants to the field while they develop a research track record provide an appropriate means of attracting new talent into this field. Such awards are not widely available for health services research in general; most fall within more specialized areas of inquiry and tend to be aimed at physician researchers.

Health services research also may be attractive to some because of the policy significance of the issues addressed. There is considerable interest in government and the private sector regarding issues of patient health outcomes, the appropriateness and quality of medical care, and the cost-containment potential of alternative delivery systems. Because both the public and private sectors are seeking answers to complex questions, the opportunities for working in an area of high visibility have expanded. This will appeal to those who are interested in applied rather than more theoretical fields of inquiry.

## INTERDISCIPLINARY TRAINING PROGRAMS

Interdisciplinary training is a relatively new--and increasingly important--avenue for producing health services researchers. Perhaps the most familiar programs are in public policy, public health, and health services or health policy research. In these programs students are introduced to a variety of methodologic approaches and taught the strengths and weaknesses of different methods for answering particular research or policy questions. This type of training introduces the individual to the contributions that can be made by different disciplines, which may be necessary in order to manage a team of researchers with different backgrounds.

The interdisciplinary training may be general (e.g., public policy) or specialized (e.g., health services research). Because there are few such programs, each one is almost a unique case, and it is difficult to generalize about the advantages and disadvantages of each approach. Perhaps it is most important to know that both paths exist and that both are likely to produce some high-quality individuals capable of conducting health services research projects. As these fields develop, however, this may become a more efficient and effective means of producing health services research personnel. For those in interdisciplinary programs, the major issues are the following:

- the availability of such training programs relative to the number of applicants;
- the ability of such programs to attract high quality students; and
- career opportunities that are open to graduates of these programs.

Currently, there is no information on any of these three issues. What would be required in order to answer these questions is a comprehensive listing of interdisciplinary training programs and a survey of them. Admissions data combined with interviews of program directors could be used to answer the first two questions. In particular, it would be helpful to know what types of individuals are likely to pursue these programs (e.g., recent college graduates, individuals with related job experience, individuals making career changes) and how they compare with typical applicants to graduate programs in the disciplines from which health services research draws.

The third question might be best addressed through a survey of alumni of these interdisciplinary training programs. Because these programs are relatively new, it is unlikely that one could piece together a career history (e.g., one that follows individuals from graduation through retirement), but early career paths could be documented. It is important to note that a variety of career opportunities are available to individuals trained in interdisciplinary research. Because many research results may suggest needed changes in policy, there are benefits to having trained individuals who are responsible for policy formulation and implementation.

## POSTDOCTORAL TRAINING PROGRAMS

Individuals trained in either disciplinary or interdisciplinary programs may require additional career development such as that offered in postdoctoral training programs. These programs may serve different purposes, depending upon the background of the individuals entering the program, but all should enhance the quality of research produced and provide research experience that will advance the careers of these persons. For those with professional degrees (e.g., medicine, law), the postdoctoral program may serve to introduce the individual to research methods. For persons with doctoral training in a specific discipline, the postdoctoral training program may provide an opportunity to specialize in health services research. For those with interdisciplinary degrees, the postdoctoral program may offer additional experience in designing and managing research projects. Each of these functions is important, and because of the multiple pathways into health services research, each will continue to serve a purpose in the future. The issues in this area are:

- What are the key components of successful postdoctoral training in health services research?
- What is the demand for positions in these programs relative to the availability?
- Do such programs influence the career paths of their graduates?

Despite the multiple pathways into health services research and the variety of disciplines that participate, there may be a basic set of skills necessary in order to have a successful career in this field. Two important components in many health services research projects are a clinical perspective and methodologic expertise. These reflect the two levels at which analysis generally is conducted in such projects: at the doctor-patient level (clinical) and at the level of a particular group (policy).

Physicians, by virtue of their medical training and experiences, can bring a clinical perspective to health services research, but, in order to contribute to the formulation of research questions and study design, they also must be trained in research methods. Physicians are trained to approach each patient as a unique case, rather than to take the aggregate approach to formulating questions and collecting data that are required for conducting research. Thus, most physicians require training in research methods to acculturate them to the language and framework for problem solving.

Methodologic experts, on the other hand, provide a perspective on the design and conduct of research projects, but they may require socialization or training about the important clinical issues. For example, much interest has been expressed by Congress and others in devoting additional resources to patient-outcome research. A methodologic expert might be able to frame the questions but would require assistance in designing a medical records abstraction form, including making decisions about the critical values (e.g., what diagnostic test result justifies performing coronary artery bypass surgery). Alternatively, a cardiologist could suggest the key outcomes of bypass surgery that might indicate whether high-quality care was being delivered, but he or she might require assistance from an epidemiologist or statistician to design a study to estimate the prevalence of quality problems.

Estimating the demand for entry to postdoctoral programs should be approached in a manner similar to that suggested for interdisciplinary training programs. A comprehensive list of the postdoctoral programs and a survey of program directors that included information from admissions records would provide information on, for example, the number of qualified applicants turned down each year. It would also be useful to know what alternatives applicants to these programs are considering.

Finally, although there seems to be logic in developing postdoctoral training programs, it would be useful to know the outcomes of these programs and whether they have any substantial influence on the quality and success of graduates:

- Does postdoctoral training improve the ability of individuals to obtain research funding?

- Are researchers who have been through such programs more likely to have articles accepted for publication?
- Are they able to publish in higher-quality journals?
- Are they more likely to stay in research careers?

Answering these questions would require a survey of alumni and an examination of the backgrounds of successful and unsuccessful applicants for health services research funds.

## ON-THE-JOB TRAINING

The final pathway into health services research is on-the-job training. Probably anyone who is conducting health services research has had some on-the-job training because it is a common means of career development. In the university setting such opportunities are provided through research assistantships or internships. Students may form mentor relationships with research supervisors, who in turn take responsibility for schooling the student in the methods and knowledge central to the chosen field of study. In all research settings this may be the method by which disciplinary-trained individuals are socialized into health services research (e.g., by serving as the economist on a health services research project). Reliance on this method of producing health services researchers is risky at best because the success of the approach depends upon the quality and commitment of those serving in a supervisory capacity. If the supervisor perceives his or her role as a teacher or mentor and is capable in either of those capacities, then the individual in training is more likely to have a successful experience. Many research projects, however, are constrained by tight budgets that may not allow for adequate learning opportunities. Motivated individuals may be able to learn even under such circumstances, but we would hardly want to depend upon this approach as the sole means by which such researchers are produced.

## HEALTH SERVICES RESEARCH REQUIREMENTS

The field of health services research would be advanced by establishing some guiding principles about the requirements to become a health services researcher. From the taxonomy proposed in Figure 1, a first step could be taken to recommend areas of exposure. While there is no one pathway that should be required, it is reasonable to consider how we would want to train the next generation of researchers in this area. A proposed curriculum is outlined in Table 5 as an example of the areas of study recommended for those in health services research. Presumably, some researchers would be experts in one of the fields listed in the table, but they would also have been exposed through a combination of formal course work and research experience in some proportion (say two-thirds) of the other disciplines that contribute to leading health services research projects. The knowledge of these other fields is important both in formulating research strategies and managing projects that utilize multiple disciplines.

## SUPPORT FOR HEALTH SERVICES RESEARCH TRAINING

From the above discussion, it should come as no surprise that the field of health services research draws upon a variety of sources of funding for training. These sources include both public and private support. Those more easily identified are the sources dedicated to health services research training fellowships; clearly, this does not capture all of the funding sources for training those who become health services researchers. The AHSR maintains a directory of Health Services Research Organizations. The 1988 directory provides profiles on more than 80 health services research centers, including information on the number and funding for training fellowships. The appendix to this paper contains a listing of the predoctoral, postdoctoral, and other training support based on information provided in the directory.

As can be seen from Table 6, the number of fellowships available for training in health services research is quite small. Although this number most likely underestimates the true number, it probably captures the majority of available fellowships in major institutions. It also should be emphasized that these numbers represent fellowships specific to health services research and do not include individuals receiving disciplinary training who may eventually enter health services research through other channels. It is also worth noting that these programs exist in only a few states (15 or 16), which suggests that access to these programs is limited geographically. California and Massachusetts have the largest number of institutions offering predoctoral and postdoctoral training programs. Financial support for these training programs comes from both government and private sources.

### FEDERAL SUPPORT

A number of agencies within the federal government provide funding for both research and training activities. The most prominent agencies are within the Department of Health and Human Services (DHHS) and include the National Center for Health Services Research and Health Care Technology Assessment, the Health Care Financing Administration, the National Institute of Mental Health, and the National Institutes of Health. Outside DHHS, health-related research activities (although not necessarily health services research) are funded by the

Departments of Agriculture, Commerce, Defense, Education, Energy, Interior, Labor, and Transportation, as well as the Consumer Product Safety Commission, Environmental Protection Agency, Agency for International Development, National Aeronautics and Space Administration, the National Science Foundation, and the Veterans Administration. It is difficult to estimate what proportion of the health-related research conducted by these other agencies falls into the category of health services research. Such an estimate would require a separate study that has not yet been done, although it was recommended in the last report to Congress.

The National Center for Health Services Research and Health Care Technology Assessment (NCHSR-HCTA) is one of the two agencies primarily responsible for funding health services research. Table 7 shows the allocation of funding for NCHSR-HCTA since 1986. Although current dollars remain stable, the real dollars available for such research have been declining since the inception of the center. Further, new money is being added in specific research areas (e.g., patient outcomes and AIDS research) rather than being made available for general research funding. In fiscal year 1988 NCHSR-HCTA funded 40 new grants in the following areas:

- patient outcomes research;
- AIDS-related projects;
- rural hospitals;
- emergency medical and intensive care;
- prenatal care;
- technology assessment;
- role of market forces;
- home health care; and
- other policy concerns.

Grants were awarded for periods of 1 to 5 years, although most grants were for 2 years. The total amount obligated was $8.6 million.

NCHSR-HCTA also provides support for predoctoral and postdoctoral training. The agency has authority to award 10 to 20 dissertation grants annually to support individuals pursuing degrees in fields related to health services research while they write dissertations. The grants may be up to $20,000 annually and must be related to the current funding priorities of the agency. NCHSR-HCTA also has authority to award individual

National Research Service Awards for postdoctoral training related to preparation for an academic career as well as for experience in applying research methods to the study of the organization, financing, and delivery of health services. Awards may be for periods ranging from 1 to 3 years. In fiscal year 1988, about $1.3 million was available for such grants; approximately 25 percent is devoted to individual awards, and the remainder supports institutional awards. The institutional awards are designed to help institutions provide the training support that is required for both predoctoral and postdoctoral programs. Thus, some of the funds may be used for faculty development activities or program support costs, but the major focus is on providing direct training support for postdoctoral candidates. Institutional awards may be made for periods of up to 5 years and may be renewed, but individuals receiving support through institutional programs are subject to the 5-year (predoctoral) and 3-year (postdoctoral) limits imposed on individual awardees.

The other major source of federal funding for health services research is the Health Care Financing Administration's Office of Research and Demonstrations (HCFA-ORD). Table 8 shows funding levels for 1986 to 1990. HCFA-ORD has indicated that it currently supports the following seven areas of primary interest for funding research activities:

- access to quality care under Medicare and Medicaid and improved methods for measuring quality and effectiveness of care;
- refinement of the current Medicare physician payment methodology through the study of the causes for the growth in Medicare outlays for physician services and the development of cost-effective approaches to controlling such growth;
- increased competition and consumer choice and continued growth of Medicare capitated systems;
- continued improvement in the current Medicare hospital prospective payment system and the study of the outpatient delivery system;
- analysis of other Medicare and Medicaid program services and issues leading to increased efficiency in health care delivery and financing, particularly in program areas that have a significant impact on program and beneficiary expenditures (high-cost, high-volume services), including such areas as clinical laboratories, home health and long-term care, and treatment of acquired immunodeficiency syndrome;

- refinement of the current long-term care delivery and payment systems under Medicare and Medicaid; and
- studies related to the Medicare Catastrophic Coverage Act of 1988, particularly issues related to the impact of this legislation on program implementation and beneficiary behavior.

HCFA-ORD funds research through both contract and grant/cooperative agreement mechanisms. The above priorities reflect those for the grant/cooperative agreement category. Both contract and grant award studies are conducted through a competitive bidding process. HCFA also maintains four policy research centers that are designed to assist HCFA in conducting short-term policy analyses and other analyses that support HCFA's mission. Although HCFA-ORD does not support the training of health services researchers directly, the projects funded through the agency provide research opportunities for individuals pursuing both predoctoral and postdoctoral training. A study of the adequacy of training support should include the use of such research funding to provide assistantship positions for persons in training.

The Veterans Administration (VA) has two programs that provide training support. The VA Health Services Research and Development Field Program is a predoctoral training program run in nine centers nationally. Funding levels for 1987 are shown in Table 9. The program provides support for individuals pursuing a Ph.D. in numerous disciplines, including epidemiology, nursing, social work, and psychology. Candidates are nominated by the local field program, and final selection is made by the central office. Most awards are for 1 year, although an additional year of funding is possible through approval of a renewal application. A small training stipend (approximately $9,300) is provided to offset costs of research and living expenses. The VA also runs a postdoctoral training program for physicians who are working on a masters in public health focused on health services research training. There are about 12 such fellows participating in the program each year. The postdoctoral program is designed as a 2-year program and provides some support for research projects ($1,000 to $4,000 annually). For both the predoctoral and postdoctoral programs, candidates must demonstrate that their research is relevant to issues faced by the VA in the delivery of services.

## PRIVATE FUNDING

The private sector, particularly philanthropic foundations, also plays an important role in funding health services research and training. The private sources of funding listed in the AHSR 1988 directory include the following: The Bush Foundation, The John A. Hartford Foundation, The William and Flora Hewlett

Foundation, The Robert Wood Johnson Foundation, The Henry J. Kaiser Family Foundation, The W. K. Kellogg Foundation, The Andrew W. Mellon Foundation, The Pew Charitable Trusts, and the Retirement Research Foundation. These foundations contribute to training both directly, through the support of predoctoral and postdoctoral programs, and indirectly, through funding research.

The two most established direct training programs are The Robert Wood Johnson Clinical Scholars program, which provides postdoctoral training for physicians, and The Pew Charitable Trusts Health Policy Program, which funds predoctoral and postdoctoral training in health policy. In 1987 The Robert Wood Johnson Foundation provided $1.89 million to support 53 physicians training in 6 programs around the country. The Clinical Scholars program has operated since 1969 and has produced 471 alumni from 12 programs (including the 6 that are currently funded). Table 10 shows the funding levels for 1987.

Since 1982 The Pew Charitable Trusts has funded an interdisciplinary health policy fellowship program. Table 11 shows the programs along with current funding levels, the number of fellows, alumni, and type of program. Over the 4-year period of the current awards, Pew is devoting $7.4 million to this program. Each of the programs provides a slightly different focus. Boston University and Brandeis University jointly offer three programs in health policy studies. The doctoral program is a 2-year multidisciplinary program leading to a Ph.D. in health or social policy at the participating institutions. The Fellows Program is designed to develop new leadership in national health policy from the corporate sector. The Associates Program is designed to assist corporate and local government leaders from communities nationwide to develop and evaluate alternative policies for health care cost containment. The University of Michigan program is a nonresidential doctoral program in public health directed at individuals who have experience in health policy and will continue working full time while pursuing their degree. Candidates attend classes for the first 2 years during one weekend each month (Thursday through Sunday). During the third year, fellows spend three such weekends on campus. The RAND/UCLA program provides predoctoral support for individuals enrolled at either The RAND Graduate School of Public Policy Studies or the UCLA School of Public Health and runs a 1-year midcareer program. The University of California at San Francisco offers 2-year postdoctoral fellowships to social scientists, physicians, and other health professionals. The program is designed to prepare such individuals for leadership roles in health policy and health policy research.

## FUTURE EVENTS

In the absence of a crystal ball, it is difficult to predict what future events might affect the demand for and supply of health services researchers. What seems clear today, however, is that we are spending an enormous amount of money on a variety of services about which we know surprisingly little. Understanding which health care services are likely to benefit whom will require a considerable commitment of research resources and a group of researchers with specialized skills. Only a few of those currently conducting health services research have those skills. To bound the problem, this section summarizes some of the information about current rates of growth in research and training funds and provides broad estimates of what would be required for a large-scale commitment of resources.

Both the demand for and supply of health services research personnel have grown in the past decade. Although there is no systematic information giving a baseline figure and demonstrating the rates of growth over time, there is evidence of growth from information collected by AHSR. Membership in the professional organization has increased from 60 members in 1982 (its first year in operation) to more than 1,000 individual and 70 institutional members in mid-1988. In 1983 the directory listed 37 university-based health services and policy research organizations and 8 VA Health Services Research and Development Field Programs. By 1988 the number of university-based centers had grown to 54; there were 22 public and private policy analysis and research organizations and 9 VA programs.

After a substantial decline through the late 1970s and early 1980s, research funding through NCHSR-HCTA has increased 258 percent between 1986 and the President's 1990 budget. The 1-year increase between 1989 and 1990 is estimated to be 46 percent. Two policy areas are driving these increases: patient outcomes and AIDS-related research. The funding increases signal congressional interest in devoting resources to studying some of the complex problems facing health services delivery. As the field matures and becomes more sophisticated, demands for more highly trained individuals are likely to increase. Thus, it seems likely that demands for more and better trained researchers will continue.

Whether demand will outstrip supply can only be speculative at this point. The real question is whether the public and private sectors will make a commitment to understanding how best to spend scarce health resources. Work force estimates for this field would be useful but require some systematic effort to collect the necessary data. One way of looking at the demand is to estimate the number of full-time equivalent (FTE) researchers required to conduct research under the 1990 HCFA and NCHSR budget estimates. If an FTE is valued at $100,000 annually (salary, fringe, and overhead), then the 1990 budget (about $98 million) would require about 988 FTEs to conduct research. This includes individuals within the government administering the research as well as those actually conducting research. Current AHSR membership is about 7 percent higher than that FTE estimate.

Although such membership does not represent the universe of those participating in such research, it also includes individuals who are not engaged directly in research. It is safe to guess that demand and supply are about in equilibrium. However, there is evidence that the political will exists to expand such research, which suggests that demand may be starting to exceed supply. For example, Congress has allocated funds to study the effectiveness of the most commonly used procedures. If $1 million each was allocated to examining the 50 most common procedures, 500 researchers would be required for this effort. The majority of these individuals would need to be specially trained and thus new entrants.

Another way of estimating future demand is to envision expenditure about 1 percent of total health care expenditure on health services research. In 1987 health care expenditures were $500.3 billion, of which $443 billion was spent on personal health services. Spending 1 percent would suggest a $4.4 billion health services research budget, which implies about 44,000 FTEs. An increase of this magnitude seems unlikely, but it is equally clear that the demand for trained individuals is increasing and will continue to grow. Some quick response will be possible through migration of researchers out of other areas of inquiry and into health services, but too great an influx of researchers untrained in the field may cause an inefficient use of research funds.

Finally, it is fair to speculate that the problems facing the health care delivery system are not likely to be solved soon or easily. The population will continue to age and suffer from chronic diseases; AIDS will affect greater numbers of individuals; substance-abuse treatment costs will continue to climb; and the gaps between the rich and poor in terms of access to care will continue to grow. These are but a few examples of the types of issues health services researchers will be asked to study in the coming decade. While there does not seem to be a crisis in the availability of research personnel currently, the pipeline required to produce such individuals is sufficiently long to warrant conducting more sophisticated work force estimates now rather than when a problem is upon us.

## CONCLUSION

Any serious effort to address the goal of using scarce health care resources effectively will require a significant increase in the number of trained research personnel. Little systematic information is available on the adequacy of training for health services researchers. The field is both new and developing and would benefit from a serious examination of many of the questions that have been raised in this paper. Given the interest expressed by Congress and the private sector in obtaining answers to complex questions about the quality and availability of health services, the demand for individuals with such training is likely to continue to grow. Any examination of the need for individuals who are trained in health services research should include both the public and private sectors.

The field of health services research requires the participation of multiple disciplines, thus contributing to the difficulty in estimating the adequacy of supply either currently or in the future. Although the field is likely to continue to draw on multiple sources, centers that provide the necessary interdisciplinary training are becoming increasingly important and are essential for any large-scale effort to define practice guidelines and evaluate the effectiveness of medical care delivery. In the future, preference should be given to supporting these interdisciplinary or multidisciplinary training programs.

The number of fellowships available for both predoctoral and postdoctoral training is relatively small: 216 predoctoral and 133 postdoctoral fellowships (including the Robert Wood Johnson clinical scholars program) were identified. Assuming 2-year postdoctoral and 5-year predoctoral programs, this suggests that an additional 110 researchers per year are being produced. This number of fellowships is too small to ensure that an adequate supply of researchers is available in the future. Assuming that there are currently about 1,000 researchers and that fellowships ensure 100 net additions annually (and also assuming that about 10 per year retire from the field), it would take about 10 years to double the supply. A systematic study is necessary, however, in order to estimate the support that would be required to meet future demands.

The delivery of health services represents a major expenditure for both the private and public sectors. Training individuals who are capable of analyzing the most effective and efficient means of delivering such services should be a high priority. The problems addressed by health services research are complex and not likely to be resolved in the foreseeable future. The benefits of training researchers and policy makers capable of studying these problems are likely to exceed the costs. The private sector has demonstrated its willingness to participate in this effort by developing predoctoral and postdoctoral training programs. The private sector also is an important player in funding health services research. Without a substantial investment in future research and training, we have little hope of understanding, in a scientifically valid manner, how to target health care spending effectively. Many of the necessary analytic tools are in place; what we require is the political will to tackle the problem in the form of increased funding for research and training.

# TABLES

TABLE 1: Membership in the AHSR, by Discipline, as of May 1988

| Primary Discipline | Percent of Members (n = 1042) |
|---|---|
| Medicine | 18.1% |
| Economics | 13.2 |
| Public health | 12.7 |
| Sociology | 7.4 |
| Business/management | 6.8 |
| Health services research | 5.3 |
| Quantitative methods | 4.8 |
| Other health professions | 4.8 |
| Public administration/ policy | 4.7 |
| Psychology | 3.6 |
| Other professional | 1.7 |
| Education | 1.5 |
| Other | 15.4 |

SOURCE: AHSR, personal communication.

TABLE 2: Educational Background of AHSR Members, May 1988

| Type of Degree | Proportion of Members (n = 1042) |
|---|---|
| Ph.D. | 50.4% |
| M.D./other health professional | 21.1 |
| Masters | 19.5 |
| Bachelors | 2.4 |
| Students in training | 1.3 |
| Other/not specified | 5.3 |

SOURCE: AHSR Reports, Spring 1988.

TABLE 3: Institutional Affiliation of AHSR Members, May 1988

| Institutional Affiliation | Proportion of Members (n = 1042) |
|---|---|
| University | 46.5% |
| Health care delivery | 15.6 |
| Health industry | 11.3 |
| Private organization | 10.8 |
| Government | 8.2 |
| Private foundation | 1.2 |
| Other | 6.4 |

SOURCE: AHSR, personal communication.

TABLE 4: 1988 Nominations for AHSR Article of the Year

| First Author | Title | Degree and Discipline | Journal |
|---|---|---|---|
| Luft, H. S.* | The Volume-Outcome Relationship: Does Practice Make Perfect? | Ph.D. Economics | Health Serv. Res. |
| Shortell, S. M. | The Effect of Regulation, Competition, and Ownership on Hospital Mortality | Ph.D. Management | N. Engl. J. Med. |
| Dubois, R. W. | Hospital Inpatient Mortality: Is It a Predictor of Quality? | M.D./Ph.D. Public Policy | N. Engl. J. Med. |
| Chassin, M. R. | Does Inappropriate Use Explain Geographic Variations in the Use of Health Care Services? | M.D. | JAMA |
| Wennberg, J. E. | Use of Claims Data Systems to Evaluate Health Care Outcomes: Mortality and Reoperation Following Prostatectomy | M.D. | JAMA |
| Goldberg, H. I. | A Randomized Controlled Trial of Academic Group Practice: Improving the Operation of the Medicine Clinic | M.D. | JAMA |
| Jencks, S. F. | Bringing Excluded Psychiatric Facilities Under the Medicare Prospective Payment System | M.D. | Med. Care |

*Winner of 1988 Article of the Year.

| First Author | Title | Degree and Discipline | Journal |
|---|---|---|---|
| Soumerai, S. B. | Payment Restrictions for Prescription Drugs Under Medicaid: Effects on Therapy, Cost, and Equity | Sc.D. | N. Engl. J. Med. |
| Feder, J. F. | How Did Medicare's Prospective Payment System Affect Hospitals? | Economics | N. Engl. J. Med. |
| Shy, K. K. | Evaluating a New Technology: The Effectiveness Electronic Fetal Heart Rate Monitoring | Ph.D. | Ann. Rev. of Pub. Health |
| Sacks, H. S. | Meta-Analyses of Randomized Controlled Trials | Ph.D. | N. Engl. J. Med. |
| Verbrugge, L. M. | Exploring the Iceberg: Common Symptoms and How People Care for Them | Ph.D. | Med. Care |
| Young, M. J. | Do Cardiologists Have Higher Thresholds for Recommending Coronary Arteriography than Family Physicians? | M.D. | Health Serv. Res. |
| Rossi, P. H. | The Urban Homeless: Estimating Composition and Size | Ph.D., Sociology | Science |
| Warner, K. E. | Health and Economic Implications of a Tobacco-Free Society | Ph.D., Economics | JAMA |

SOURCE: Brook, R. H., 1989. "Health Services Research: Is It Good for You and Me?", *Academic Medicine*.

TABLE 5: Proposed Curriculum for Health Services Research Training

| Methods | Substantive Knowledge |
|---|---|
| Economics | Technology assessment |
| Quantitative methods (statistics, econometrics, operations research) | Health professions training and supply |
| Social science research methods (survey research, psychometrics) | Quality of care |
| Epidemiology | Health care financing |
| Demography | Organization and service delivery |
|  | Outcomes assessment |

TABLE 6: Institutions Participating in Health Services Research Training

| Category of Training | Number of Fellowships | Number of Institutions | Number of States |
|---|---|---|---|
| Predoctoral | 216[1] | 26 | 15 |
| Postdoctoral | 80[1] | 23 | 16 |
| Other[2] | -- | 24 | 15 |

[1] The number shown is a minimum; some programs indicate that the actual number varies from year to year.

[2] Includes internships, midcareer training, master's level programs, ad hoc fellowships, research assistantships, independent study, and visiting scholars.

TABLE 7: Funding for NCHSR-HCTA (in thousands of dollars)

| Category | 1986 | 1987 | 1988 | 1989 | 1990* |
|---|---|---|---|---|---|
| Research | | | | | |
| Federal funds | $15,740 | $17,277 | $16,624 | $17,112 | $12,153 |
| Trust funds | 1,050 | 1,070 | 1,005 | 1,037 | 1,037 |
| Program support | 1,050 | 1,568 | 1,632 | 1,600 | 1,693 |
| Outcomes research | -- | -- | 1,945 | 5,879 | 28,000 |
| AIDS-related research | -- | -- | -- | 6,859 | 8,576 |
| One-percent funds (NMES) | | 16,000 | 15,318 | 10,033 | 11,154 |
| NRSA | | | 1,296 | 1,323 | 1,300 |
| Total | $17,840 | $35,915 | $37,820 | $43,843 | $63,913 |

* President's budget.

SOURCE: AHSR.

TABLE 8: Funding for the HCFA-ORD (in thousands of dollars)

| Category | 1986 | 1987 | 1988 | 1989 | 1990[1] |
|---|---|---|---|---|---|
| Federal funds[2] | $15,310 | $10,000 | $9,574 | $9,880 | $14,000 |
| Trust funds[3] | 14,370 | 18,000 | 18,000 | 17,233 | 19,760 |
| Total | $29,680 | $28,000 | $27,574 | $27,113 | $33,760 |

[1] President's budget.
[2] Appropriated by Congress.
[3] Set aside from trust fund collections by congressional action.

SOURCE: AHSR.

TABLE 9: VA Health Services Research and Development Field Programs, 1987

| Region | Projected Spending, 1987 | Research Staff (FTEs) | Affiliated Universities (no.) | VA Medical Centers (no.) |
|---|---|---|---|---|
| Northeast | $1,500,000 | 22.4 | 3 | 23 |
| Mid-Atlantic | 1,078,603 | 8.0 | 2 | 1 |
| Southeast and Southwest (3, 7) | 846,794 | 18.6 | 5 | 4 |
| Great Lakes (4) | 1,116,500 | 15.5 | 4 | 5 |
| Medical District 17 | 1,263,893 | 16.2 | 5 | 3 |
| Medical District 22 | 690,027 | 10.2 | 2 | 4 |
| Medical District 23 | 220,776 | 2.0 | 3 | 1 |
| Far West (6) | 1,600,000 | 9.5 | 2 | 3 |
| Northwest (6) | 544,414 | 5.1 | 5 | 6 |
| Total | $8,861,007 | 123.0 | 31 | 50 |

SOURCE: AHSR, 1988 Directory.

TABLE 10: Robert Wood Johnson Foundation Clinical Scholars Program, 1987

| Program | Funding | Number of Scholars | Number of Alumni | Year Began |
|---|---|---|---|---|
| UCLA | $272,299 | 8 | 54 | 1975 |
| UCSF/Stanford | 274,223 | 11[1] | 72 | 1969 |
| UNC-Chapel Hill | 256,370 | 7 | 53 | 1974 |
| University of Pennsylvania | 575,818 | 11[2] | 54 | 1974 |
| University of Washington | 374,187 | 9[3] | 61 | 1975 |
| Yale University | 137,123 | 7[3] | 47 | 1974 |
| Total | $1,890,020 | 53 | 341 | |

[1] Includes four VA fellows.

[2] Includes one VA fellow.

[3] Includes two VA fellows.

SOURCE: Robert Wood Johnson Foundation, personal communication.

TABLE 11: The Pew Charitable Trusts Health Policy Program, 1987-1991

| Program | Current Grant (millions of $) | Current Fellows | Number of Alumni | Program Type* |
|---|---|---|---|---|
| Boston University/ Brandeis | $2.3 | 13 | 25 | 1,3,4 |
| Michigan | 1.9 | 23 | 9 | 1 |
| RAND/UCLA | 1.6 | 19 | 28 | 1,5 |
| UC-San Francisco | 1.6 | 9 | 39 | 2 |
| Total | 7.4 | 64 | 101 | |

* 1 = predoctoral; 2 = postdoctoral; 3 = corporate fellows; 4 = associate; and 5 = midcareer.

# TRAINING OF PHYSICIAN/SCIENTISTS

*Lloyd H. Smith, Jr.**

This memorandum is directed to certain topics relating to the role of physician/scientists in the conduct of the nation's biomedical research program and how national policy should be shaped to ensure that a sufficient number of physician/scientists are available to play that role in the future. The memorandum does *not* concern itself with the training and supply of Ph.D. scientists, although this is clearly an increasingly convergent problem. Nevertheless, many of the points raised here may have more universal applicability to all scientists who direct their attention to biomedical investigation. The following questions are addressed briefly:

1. Is there a need for physician/scientists as opposed to or in addition to basic scientists in the conduct of biomedical science, both in our academic health science centers and wherever else that form of science is conducted?
2. Are there deficiencies in number or quality in the current and projected supply of physician/scientists?
3. How many physician/scientists should be trained?
4. What are the best methods for recruitment and training of physician/scientists?
5. How can the effectiveness of training programs be evaluated?

Other questions could be formulated. If answers to the above five questions could be approximated with a reasonable degree of accuracy, however, they might serve as a basis for a rational national policy.

## SPECIAL ROLE OF THE PHYSICIAN/SCIENTIST

A generation ago "medical research" was carried out largely by physicians, most of whom had relatively little formal training in science beyond that offered in the medical school curriculum. Problems were identified in clinical medicine and then pursued to whatever depth the investigator was able to penetrate from previous experience or from techniques acquired for that specific purpose. Few physicians sought rigorous training in biological science *per se* paralleling the demanding schedules required for obtaining and maintaining clinical competence. The science taught in specialty divisions of departments of medicine, pediatrics, neurology, and so on tended to be both goal-oriented and superficial. For a few clinical investigators of genius, this approach to medical research could be highly productive, but most medical investigators were poorly prepared for sustained scholarship. For some, NIH offered both a sanctuary and a postgraduate school for learning science in depth, and the success of that experience is evident everywhere today in American academic medicine. The "doctor's draft" of the past brought with it, almost as a gratuitous byproduct, a great improvement in the quality of medical research in the United States.

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* The opinions expressed in this paper are the author's and do not necessarily reflect those of either the Committee on Biomedical and Behavioral Research Personnel or the National Research Council.

During the last 30 years, the scope, scale, and sophistication of research into human (and eukaryotic) biology have been enhanced enormously. As a result, it has become the domain of the professional scientist rather than of the inspired amateur. The study of human biology in the broadest sense has spread far beyond hospitals and even medical schools and is being pursued intensively and successfully in universities and institutes with no direct commitment to medical care (e.g., MIT, Cal Tech, Harvard College, and University of California-Berkeley) and by individuals who have not been trained in medicine. These trends are clearly evident and can be documented easily by analyses of the flow of NIH and NSF funds.

What do these trends mean for the application of current revolutionary advances in biology to the prevention and treatment of human diseases? This, after all, is the basic concern of the citizens who support this science. In partial answer, several points are worthy of emphasis:

1. The remarkable progress in basic biology brings with it parallel new opportunities for human application in "clinical investigation." The seminal retrospective studies of Cumroe and Dripps (1976), for example, showed quite clearly that technical advances directly applicable to the care of patients with cardiovascular and respiratory diseases depended heavily on basic research (about 40 percent in their arbitrary definition). In effect, there is no real discontinuity between the most fundamental basic biological science and the technology of modern medicine.

2. Clinical research is not simply that which is performed by a physician. Many basic scientists carry out excellent clinical research, and some of the research done by physicians is clearly basic science. It is difficult to supply an unambiguous definition of clinical research. As a beginning, one can say that it is research directed toward the elucidation and, therefore, the control of a human disease either directly or with a reasonable degree of intellectual continuity.

3. The physician/scientist is more likely to tilt in the direction of clinical research, as defined above, than is the basic scientist. This is stated as an article of faith, based on the following driving forces:

    a. He or she is more likely to be aware of the existing problems in human health and disease and also what is important to do and what is feasible to do. This awareness is not only the product of medical education but also of the imperatives of daily experience.

    b. He or she is more likely to have a primary commitment to this type of applied research because of intrinsic interest and also because of the reward systems in the environment in which he or she pursues a profession (department, school of medicine, national peer network, and societies).

4. The physician/scientist is of particular importance in medical schools in order to translate the current role and future potential of basic science during the education of future practitioners. Those currently in medical school and in postdoctoral training will have their main professional experiences in the twenty-first century. That fact implies enormous changes in the technological basis of medical practice in ways that cannot now be foreseen. Only those educated in the spirit of scientific inquiry can hope to remain abreast of this continuously changing frontier.

5. Uniquely in medicine, the university is involved directly in operating a major industry--that of health care. In all other disciplines the university is divorced from the direct practical application of what it learns and what it teaches. In this type of "industrial setting" that exists in the clinical departments of all medical schools, it is of particular importance to have those who can serve on the interface between what is best in science (the university role) and what is best in medical practice (the industrial

role). This can best be done by those who have authentic credentials in both domains.

For all of these reasons, and perhaps others as well, it is very important to maintain a strong contingent of physician/scientists in American medicine, recognizing that they may have to compromise somewhat in both areas of activity. They are unlikely to be the best clinicians in their respective hospitals because clinical skills are not honed in the laboratory, and they may not be the most productive scientists because they will need to commit extra time for maintaining basic clinical competency. Unless some are successful in such an amphoteric existence, however, medical schools will fragment into "two societies," as C. P. Snow described in another context some years ago.

## SUPPLY OF PHYSICIAN/SCIENTISTS

Do we have a sufficient number of physician/scientists at the present time? The general consensus is that we do not, although this is an area in which it is difficult to obtain data. First of all, the physician/scientist is not a standard unit. Perhaps we should invent a new scale of "competency units" in which to attempt such measurements. The diminishing effectiveness of the physician (in comparison to the Ph.D.) in competition for NIH support has been well-publicized. Perhaps of greater concern is the difficulty encountered by every search committee that seriously attempts to identify physician/scientists for academic appointments within even our most prestigious, research-intensive medical schools. Within given disciplines (e.g., cardiology, gastroenterology, etc.), the number of physician/scientists who have attained some clinical competence and who could also meet the stringent criteria for scholarship for appointment in a basic science department is incredibly small. It is widely perceived that the paucity of such individuals who are competent in modern science and some phase of clinical medicine is the main limitation in our ability to move ahead quickly in modern clinical research. This is the most valid reason for the current move to create institutes or departments of "molecular medicine," or some variation on that theme, in order to obtain the climate in which such work can prosper. But the number of currently available physician/scientists who can do distinguished work in these areas is limiting. In summary, we may have a reasonable number of physicians who have participated in some form of research, but we do not have enough who have undergone rigorous preparation for scientific careers.

## HOW MANY PHYSICIAN/SCIENTISTS SHOULD BE TRAINED?

An excess. This is not a facetious answer. Scientific ability does not parallel intelligence and hard work. Some very bright people are relatively ineffective as working scientists;

others less intellectually gifted are highly competent as scientists. Creativity in science cannot be predicted with any confidence; it can only be demonstrated over time. The cost of scientific training is comparatively modest when balanced against projected expenditures during a career in science. For all of these reasons, it is a better strategy to train an "excess" of scientists and then to continue to support only the best for subsequent research. The basic purpose of science policy, after all, is not to employ scientists but to ensure that the nation's goals in research and education be met. Therefore, the focus should be on the results obtained rather than on the number of scientists employed. There are many secondary gains for expanded training of physician/scientists, even for those who do not remain in this arena of activity. For science itself they furnish useful workers who contribute to the completion of the investigative projects in which they are being trained. Of equal importance, the individual benefits from learning further about scientific method and thereby is better prepared to evaluate medical progress and to learn to adapt to a career in the practice of medicine for the twenty-first century. Extra scientific training for the physician should not, therefore, be considered as a waste of resources.

The ability of our nation to predict future work force needs has not been impressive in science or in medicine. It is patently impossible to predict with any degree of precision the needs for a system that is undergoing vast fluctuations. Because of this, it is generally more prudent to overshoot rather than undershoot, particularly in view of the fact that the process of training a physician/scientist is a very long one, perhaps eight to ten years. This process is, therefore, inherently sluggish in its response to market forces or attempted social engineering.

Even if it were possible to predict with some precision the number of future available positions for physician/scientists in academia, industry, public service, and other venues, this figure would not furnish a rational basis for the number to be trained. As noted previously, investigators vary widely in productivity and creativity and therefore do not represent a standard product. There is probably a finite pool of candidates who are capable of the highest level of sustained creativity. The real challenge in scientific work force policy is to identify the candidates and to bring them to fruition as scientists, realizing that this can be done only by training many and choosing the best from among them.

## Methods for Recruiting and Training Physician/Scientists

### Current Barriers

It might be useful first to consider briefly the current barriers to attracting the best young physicians into scientific careers. Since there are few useful data concerning this theories abound. Some are as follows:

1. The deterrent effects of personal indebtedness. Here data are available concerning the increasing indebtedness of medical school graduates (about $30,000-$40,000 for public schools and about $40,000-$60,000 for private schools, with wide ranges beyond these averages). Such debts clearly reduce the ability of the student to electively undertake yet further training at low compensation directed toward a career with modest long-term fiscal rewards.

2. The increasing stretch in trying to maintain competency in both science and medicine as both become more demanding. This creates continuing tensions for the individual who attempts a career that bridges both domains.

3. The perceived insecurities of academic life based on the vagaries of short-term extramural funding for research. Current investigators transmit these insecurities to those who are considering similar careers.

4. The current "industrial turmoil" in clinical departments as they contend with the demands for health care delivery and financial viability in a time of change. The resulting harassment is not lost upon the young.

5. Possibly changing levels of expectation. More students are married or have other elective obligations than in the past and may be less willing to undergo the longer periods of relative privation to prepare for a research career.

6. The attractiveness of medical practice. Some of this attractiveness relates to the immediacy of personal gratification in helping other human beings as opposed to the qualitatively different and often deferred rewards of medical research.

There are many other factors as well, including the absence or paucity of suitable role models, jam-packed medical school curricula based on fact engorgement rather than on problem solving, and the end of the doctor's draft. Obviously, all of these deterrents will occur in a different silhouette for each student.

## General Principles of Training

There is no single best method of training the physician/scientist (i.e., best for each individual and for every setting).

It is noted that most scientists tend to recommend the type of pathway that guided their own careers. This topic can be considered usefully under four headings:

1. **Entrapment of the young:** Ideally, there should be a period of research prior to or during medical school in order for the student to decide whether he or she enjoys this activity and is good at it (the two factors generally coexist). Time should be made available for this in the medical school curriculum or in arrangements for summer laboratory experiences. It is important for every student to learn something in depth--to penetrate to the frontier of knowledge, however narrow the subject may be. For some the intense trial period for research may be extended usefully for up to a year. Such a period is necessary in order for both the student and the sponsoring agency or department to decide whether a more extensive investment of time and money is warranted in his or her training.

2. **Training in depth:** It is imperative that the serious physician/scientist receive training in depth in a scientific discipline relevant to medicine. It is both inaccurate and arrogant to assume that the intensive professional training of a physician prepares him or her to compete in modern biological science with a scientist who has undertaken the rigorous discipline of a Ph.D. degree. Rarely can this type of training in science be achieved in a specialty division of a clinical department (although there are some exceptions here). Whether this training fulfills the formal requirements for a Ph.D. degree probably is immaterial, but it should be comparable to such a program in rigor and scope. During this time, the physician should not attempt to carry out parallel clinical duties, which will only serve as a diversion from his or her critical opportunity to become a serious scientist (or to demonstrate to himself or herself and to others that such a career is not his metier).

3. **Coordination of scientific and clinical training:** The coordination of clinical and scientific training is a vexing problem that defies an easy solution. This simply presages, however, the future problems that the physician/scientist will have throughout his or her subsequent career in coordinating a role as both a physician and a scientist. In general, there are two approaches, each with some advantages and disadvantages:

a. *Pre-M.D. scientific training*: The prototype here is the M.D./Ph.D. program. The advantages are an earlier commitment to science in depth and continuity with the standard basic science of the medical school curriculum. Another advantage is that the individual has this extra scientific competency at his or her command during the intensive clinical experiences of the senior year of medical school and the years of residency training. The obvious disadvantage is the enforced hiatus (usually at least three years) between the completion of thesis work and the chance to return to full-time science. Many of these same considerations would hold for more extensive non-Ph.D.-directed scientific experience during medical school or for the individual who has obtained a Ph.D. prior to entering medical school.

b. *Post-M.D. scientific training*: The prototype here is NIH or NIH-equivalent experience that many current investigators obtained in the past. The advantages are that at this stage of maturity the individual is perhaps more likely to know his or her future plans and also that the work can continue without serious interruption following the training period. A theoretical disadvantage is that the individual may by now have firmly decided upon a clinical career without having had a serious look at the alternative of research. In addition, accumulated debts may by this time have diminished the feasibility of investing the necessary additional years for research training.

Either model can be effective as demonstrated by those in academic medicine today. In this brief outline above, little consideration was given to the financial implications of these alternatives, since these would vary depending on the existing means of support--for example, the full support provisions of the federally sponsored MD/PhD program.

4. **Launching a career**: The beginning years of a career as a physician/scientist are of vital importance as the individual attempts to establish an independent program as a scholar. During this transitional period, such individuals require protected time and should not be required to participate as heavily in departmental activities (patient care, teaching, and university service) as do those who are not making a similar effort to bridge basic science and medical research.

This topic is directly pertinent to the future supply and viability of physician/scientists in clinical departments, but it is not discussed here further.

## MODELS FOR TRAINING IN DEPTH

As noted previously, there are many possible models for training for research for the physician/scientist. Individuals with exceptional motivation and talent can develop successful scientific careers through any one of these or other pathways.

1. **M.D./Ph.D. programs:** In the M.D./Ph.D. programs the student pursues a regular Ph.D. degree, usually after the second year of the standard medical school curriculum, in one of the basic science departments of his or her institution. The Ph.D. training often can be somewhat truncated (three years) because of the student's previous course in science, but it is usually not shaped specifically for the physician-to-be. These programs have been judged to be highly successful as judged by the number of participants who have remained active in science and who have achieved independent research funding through peer review mechanisms. The pros and cons of this mode of training for research have been listed previously. Data concerning the outcome of NIH programs are readily available. It is the general opinion that this pathway should be retained and expanded. Not least of the positive features is that the trainee usually is able to avoid or attenuate the burden of personal debt. Since these programs are well-defined and have been analyzed thoroughly, the M.D./Ph.D. pathway is not considered further here. It seems clear that such programs should continue to receive high national priority.

2. **Postdoctoral fellowships for the physician/scientist:** At least three years of rigorous training in modern biological science usually is necessary for most individuals, however gifted, to arrive at a stage of independence as an investigator (Goldstein, 1986). In fact, the period of time may be longer and require the equivalent of the "post-doc" experience that is now *de rigueur* for Ph.D. recipients. For those who are training for a career in research, this time should not be diluted with simultaneous clinical responsibilities, which inevitably serve to divert attention and energies elsewhere. Preferably, this experience should be in an active basic science laboratory that is on the cutting edge of some discipline that is ultimately applicable to medical research and that is in the usual predoctoral, postdoctoral climate of competitive ideas and productivity. Since the boundaries of modern

biological science are pervious, it is not particularly important whether the nomenclature of the department is that of cell biology, molecular biology, biochemistry, or microbiology. The same powerful methodologies of working with peptides, proteins, receptors, DNA, RNA, monoclonal antibodies, and so on can be acquired and will have ultimate applicability to virtually any problem relating to the pathogenesis and treatment of human disease. Beyond the methodologies--and even more vital--the nascent physician/scientist will be honed in the rigors of defining problems and learning how they can be approached rationally. The physician in training to become a physician/scientist should not be concerned that the problems being pursued seem excessively fundamental and far from human biology. It is always easier to move from that which is very basic to that which is applicable than to try to learn selective elements of experimental biology as the need arises in clinical investigation.

One approach has been to establish a program of national fellowships for the postdoctoral training of the physician/scientist. It is useful to analyze the current program of the Markey Foundation (which is scheduled to be phased out over the next few years). In this program provision is also made for some assistance for the physician/scientist at the entry level of beginning faculty membership. Similarly, the Physician/Scientist Award program of NIH has endorsed this approach over the past five years, so that experience is beginning to accumulate about its effectiveness.

3. **Postdoctoral training programs for the physician/ scientist:** The M.D./Ph.D. program and the individual fellowship program for training in science were described briefly above. In general, there has been considerable experience with both modes of training. Formalized *training programs* for physicians usually have been established as appendages to specialty divisions of clinical departments (e.g., in gastroenterology, cardiology, endocrinology, etc.). The scientific training that such divisions can supply rarely approaches that available in basic science departments. Also, it is diluted frequently by simultaneous training in the parent medical discipline. It is not surprising, therefore, that many of the physicians so trained quickly leave investigative careers to enter the practice of their respective specialties. Although this process has continued to ensure a supply of scientifically trained clinicians, teachers, and clinical investigators, it has not

sufficed to develop physicians who are sufficiently well-grounded in the fundamental sciences for sustained scholarship.

These considerations have led to proposals for new forms of institutional postdoctoral training programs that would be shaped more specifically for the production of physician/scientists. Such a successful program should contain the following elements:

a. It should represent a true consortium between the clinical and preclinical departments of the institution with equal responsibility for the design and administration of the program.

b. Selection of the trainees should be made during the senior year of medical school, based on evidence of some previous experience in research and overall promise. Selection and planning then can be coordinated for both basic clinical training and subsequent scientific training. It would be advantageous to have the basic science departments participate in the selection process in order to ensure their commitment to those who enter the coordinated program.

c. Formal course work in the physical and biochemical sciences should be an integral part of any such program so that its graduates command a theoretical background comparable to that obtained by those with graduate degrees in the biological sciences. The extent of the required course work can be individualized based upon the level of prior training, but it should be rigorous and at the graduate level in the relevant disciplines (biochemistry, genetics, molecular biology, cell biology, etc.).

d. The training program should be for not less than three years, of which most will be invested in direct research experience under the supervision of a mentor.

   At the completion of this training period, which often may be extended beyond the formal three-year program, most of the physician/scientists will rejoin their respective clinical departments for subspecialty clinical training in their chosen disciplines. Some will elect to remain in basic science and will enrich those disciplines with their breadth of training and interest in human biology.

## EVALUATION OF PROGRAMS

Science is what scientists do. The logical approach would be to evaluate the scientific achievements of those who have completed a given type of training. Obviously, this is much more difficult to do than it seems at first. It is usual, therefore, to use as a surrogate a number of indirect indices, such as the number who remain in an academic environment, those who have successfully attained an RO-1 grant, or those who have remained active in research (as judged usually by grant activity) after some arbitrary period of time. None of these measures is very satisfactory since the quality of science is not appraised, other than its success at securing competitive funding. In a sense, the appraisal has been transferred to the respective study sections.

One can use other indices of peer recognition, such as election to elitist scientific societies, or one can use citation criteria or arbitrary assignments of value to publication in certain of the more stringently reviewed journals. Ultimately, most evaluations are highly subjective. Furthermore, they cannot be readily made except over extended periods of time in view of the natural history of a scientific career.

There must, therefore, be an element of faith. A program that enhances the exposure of students to science as a creative process (rather than a repository of inert facts) and that encourages and supports those who wish to pursue rigorous scientific training in depth must be assumed to increase the chance that those who are most qualified will more likely pursue careers as physician/scientists. Intuitively it seems so. NIH experience of the years of the doctors draft seems to support this supposition. It is not a rigorous method of assessment, but it may have to suffice. Furthermore, as noted previously, those who fall out of the system, that is, do not have sustained careers as productive physician/scientists--cannot be judged flatly as failures since they may well be more capable of adapting to the complexities of the practice of medicine in the twenty-first century.

## SUMMARY

In a sense, this brief position paper is in itself a summary of an opinion without formal documentation. Several points seem worthy of emphasis in future policy concerning the training of physician/scientists:

1. There is a special need for physician/scientists in the conduct of the nation's biomedical research. The increasing interest and involvement of Ph.D. scientists in medical investigation are of great importance and

benefit, but this does not replace the need for physician/scientists.

2. The number of well-qualified physician/scientists is in short supply now and will continue to be limiting in current projections. As a result, there are missed opportunities for the rapid application of modern biology to medical problems.

3. Our ability to predict work force needs is inexact, based on past record, and the responsiveness of the production system is sluggish inherently because of the long pipeline and other variables. Therefore, it is wiser to overshoot rather than undershoot in projections of work force needs.

4. The physician/scientist is not a unit of scientific competency and productivity. The nation should be less interested in the exact number of FTEs employed than in the pace of scientific progress. A wise policy therefore would be as follows:

   a. to train larger numbers of physician/scientists but retain only the best in scientific careers; and

   b. to accept the fact that this investment in training gives value received even for those who do not remain in science:

      o The cost of training is low in comparison with the ultimate investment in the scientific work of those supported; hence, it pays to allow for the choice of the best, based on performance in research.

      o The "trainees" are, in fact, modestly reimbursed laboratory workers who contribute great value to the direct conduct of research during their so-called training periods.

      o Those who leave science return to medicine better prepared to apply more critically the science of the future in their respective professional careers.

5. Four phases of training that can be defined arbitrarily:

   a. *Entrapment*: Early research experience for the medical student will help to define those who have interest and competency in research.

b. *Training in depth*: This requirement is noted below.

c. *Coordination with clinical training*: The physician/scientist must balance proficiency in both domains.

d. *Launching of an independent scientific career*: The early years of a scientific career require special consideration and protection.

6. Training in depth usually requires at least three years of experience in some phase of basic biological science. This is absolutely necessary if the physician is going to be able to serve effectively on the frontier between the best in science and the realm of medical research. Rarely can this be achieved in a clinical department as they are now constituted.

7. A number of pathways have been successful in offering to physicians this kind of training for proficiency in science. All of these models, which were described briefly here, can offer training in depth and should be continued in a balanced national program for training physician/scientists:

   a. the M.D./Ph.D. programs;

   b. national fellowship programs; and

   c. postdoctoral training programs for physician/scientists.

   The last category of specific training programs probably warrants the most attention, since such programs currently are less well-defined.

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# BIOMEDICAL/BEHAVIORAL COHORT MODEL: A TECHNICAL PAPER

*Joe G. Baker**

## INTRODUCTION

The legislation prompting this study requires the assessment of ". . . the nation's overall need for biomedical and behavioral research personnel. . . ."[1] Past committees have defined this "need" in labor market terms--that is, how many biomedical and behavioral researchers will be "needed" in the future? The purpose of this paper is to document the model used to project the future labor market for biomedical and behavioral scientists. Future labor market conditions are defined in terms of improvements or deteriorations from historical market conditions, and future demand conditions are examined in the context of the appropriate National Research Service Awards Acts variable--that is, Ph.D. production and postdoctoral study. Following a descriptive overview of the model used are detailed discussions of the various model components, data, and coefficient estimates.

## THE MODEL: AN OVERVIEW

Past committee projections of the future need for biomedical and behavioral scientists have focused on academic demand. Job openings were developed based upon growth in academic positions and openings resulting from faculty death, retirement, and field switching. These projections were developed for the near term; the 1985 committee report included projections to 1990.

This model expands the earlier analysis in several ways:

1. In almost every biomedical and behavioral field, the major source of historical and projected employment growth is in nonacademic sectors, primarily private industry. Thus, this model includes industry, government, hospital, and other nonacademic sources of demand for biomedical and behavioral scientists.

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[1] Section 489 of P.L. 99-158.

2. The focus of the NRSA program is research personnel. This analysis develops separate projections for the labor market in general and that subsection of the labor market associated with scientists whose primary work activity is research and development (R&D) or the management of R&D.

3. Given concern over "graying" of the work force, this analysis includes a demographic/economic model for estimating scientists' attrition due to death, retirement, and net occupational movement based upon the age and experience structure of the scientific work force.

4. This analysis includes a model of labor supply.

5. Given that the median time to complete the biomedical sciences Ph.D. has grown from seven years in the late 1970s to eight years in 1987, the 1997 biomedical scientist labor market will be influenced by student decisions and NRSA policy in 1989. In the behavioral sciences, median time to Ph.D. has increased from approximately 8.5 years to 10.5 years during the same period. These types of lags argue for a longer time horizon of analysis; the current study projects labor market variables to the year 2000.[2]

Figure 1 is a schematic of the labor market assessment model. The stock of scientists in time period *t* is characterized by biological age (years since birth) and career age (years since degree). Historical data provide estimates of the number of deaths and retirements by biological age; these scientists are removed from the scientist stock. Those who do not retire or die can leave the field for other employment; this is assumed to be a function of career age. These estimates of outmigration are net of inmigration from other fields and are estimated from historical data. The surviving scientist stock is available for employment in period *t*+1. The required scientist stock in period *t*+1 is estimated from submodels that link demand for scientists to the demand for the good or service that scientists produce--for example, R&D or graduate students. These demand submodels vary by discipline (biomedical, behavioral, clinical), work duties (R&D and non-R&D), and sector (academic, industrial, governmental). The difference between the surviving scientist stock and the required scientist stock in period *t*+1 is the job openings (vacancies) that must be filled by new entrants. These

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[2] See National Research Council, *Summary Report 1987 Doctorate Recipients from United States Universities* (Washington, D.C.: National Academy Press, 1989), Table P.

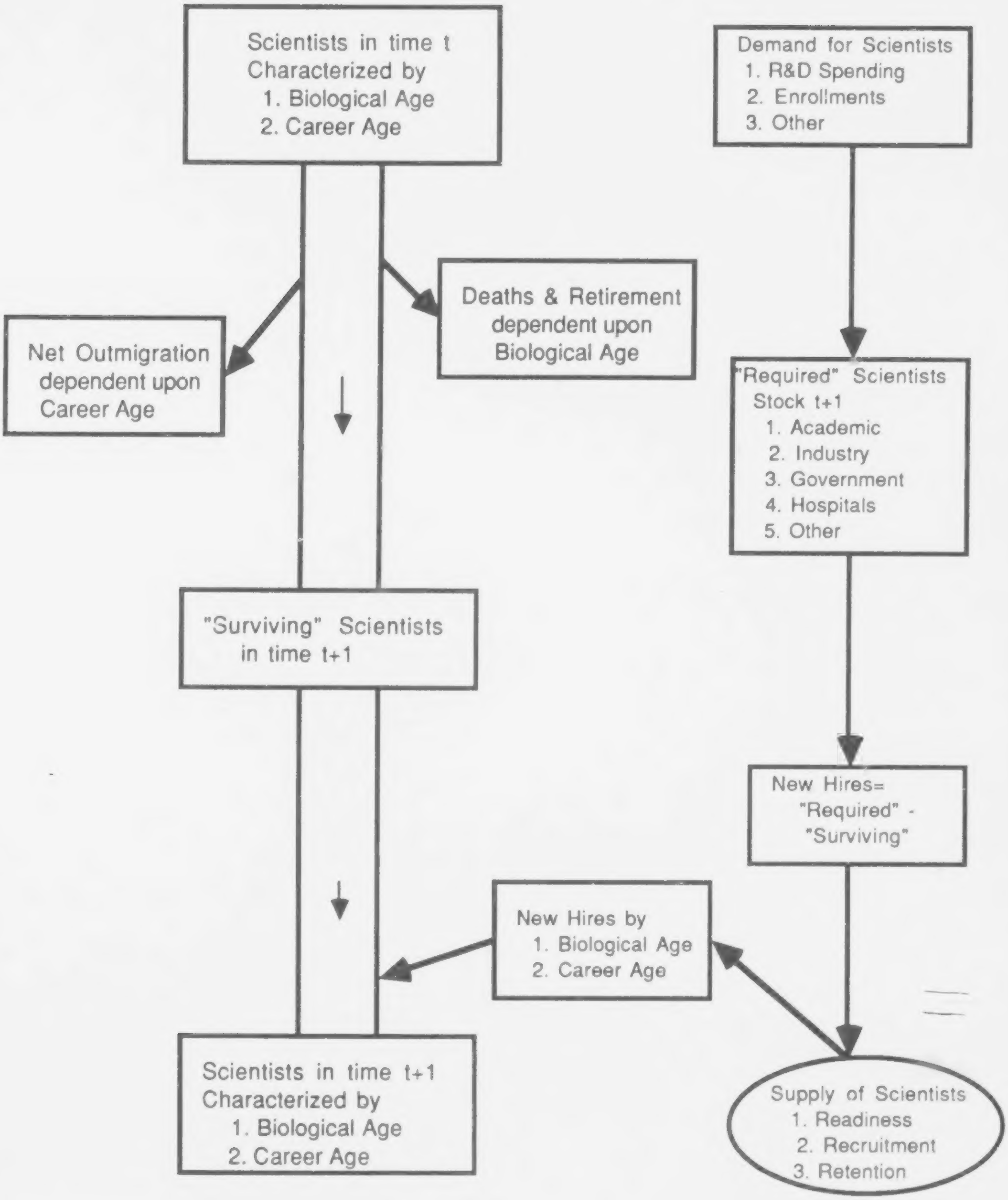
Scientists in time t
Characterized by
1. Biological Age
2. Career Age
Demand for Scientists
1. R&D Spending
2. Enrollments
3. Other
Deaths & Retirement dependent upon Biological Age
Net Outmigration dependent upon Career Age
"Required" Scientists Stock t+1
1. Academic
2. Industry
3. Government
4. Hospitals
5. Other
"Surviving" Scientists in time t+1
New Hires= "Required" - "Surviving"
New Hires by
1. Biological Age
2. Career Age
Scientists in time t+1
Characterized by
1. Biological Age
2. Career Age
Supply of Scientists
1. Readiness
2. Recruitment
3. Retention

**Figure 1.** Schematic of the Labor Market Assessment Model

job vacancies are compared to supply to compute "vacancy ratios" --that is, the number of vacancies per new Ph.D. or postdoctorate. Increases or decreases in future vacancy ratios from historical ratios give one a sense of tightening or loosening of the projected demand/supply balance in the scientist labor market. This same basic analysis is replicated for the R&D subsector.

## SCIENTIST ATTRITION: DEATH, RETIREMENT, AND NET MOBILITY

The model used to estimate attrition is a demographic/economic cohort survival model that follows closely the work of Kuh, Radner, and Fernandez.[3] The nature of a cohort survival model is to essentially "march" each cohort of scientists through time and apply age-specific rates of death, retirement, and net outmobility as the cohort ages. The population described here is that of basic biomedical scientists. Separate coefficients were estimated for behavioral scientists and are included in the Appendix tables.

Three types of annual scientist attrition are addressed by the model: death, retirement, and net outmobility. The annual number of deaths and retirements are assumed to be a function of an individual's "biological" age (B). Annual net outmobility is defined as the number of scientists who leave biomedical science for other occupations minus the number of workers who enter biomedical science from other occupations. Net outmobility is assumed to be a function of a scientist's "career" age (C). It is unlikely, for example, to see a large net outmobility rate in the younger career ages because scientists are unlikely to move out of an occupation that has consumed an average of 8 years of training. Later in their careers, a segment of the scientists will more likely move out of science and into administration or management.

In addition to career patterns, scientist mobility could be influenced by labor market characteristics. For example, if the labor market deteriorated and job opportunities and wage growth were depressed, scientist outmobility would probably increase. However, historical data indicate very little variation in scientist unemployment and underemployment rates through time. Also, it could be argued that scientists would be unlikely to leave a career in reaction to short term cyclical economic conditions. In the model described here, these labor market influences are assumed to be small compared to career patterns as determinants of net mobility, i.e., they are ignored.

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[3] Charlotte Kuh and Roy Radner, *Mathematicians in Academia: 1975-2000* (Washington, D.C.: Conference Board on the Mathematical Sciences, 1980); and Luis Fernandez, *Project on Quantitative Policy Analysis Models of Demand and Supply in Higher Education* (Washington, D.C.: Carnegie Council on Policy Studies in Higher Education, 1978).

Each scientist in the model is defined by biological age and career age. Although scientists can enter the system at any career age, those who enter at career ages other than one are incorporated into the net outmobility rates. For practical purposes, all new entrants enter the system at career age one. The parameters of the model include:

- Initial biological and career age distribution,
- Biological age-specific death and retirement rates, and
- Career age-specific net outmobility rates.

Obviously, there is a high degree of correlation between biological age and career age. Because of this, one can estimate fairly accurately the biological age distribution of a group of scientists given their career ages. If one assumes that the biological age distribution of newly minted Ph.D.s is stable, one can construct a model whose states (biological age and career age) depend only upon the career age distribution. At any time, the biological age distribution can be estimated from the career age distribution and the model can be simplified.[4]

## Data

Except where noted, all data are from the Survey of Doctorate Recipients (SDR) sponsored by the National Science Foundation and the National Institutes of Health. These data are collected by the National Research Council biannually from a cross-section sample of approximately 10 percent of the U.S. Ph.D. scientist population.

## Initial Career and Biological Distribution

Table 1 is a cross-tabulation of the distribution of biomedical scientists in 1987 by career age and biological age. Given that a biomedical scientist is $C_{<=5}$ ; then $P(B_{<30}) = .115$. These probabilities allow the estimation of biological age from a given career age.[5]

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[4] See Fernandez, *op. cit.*, pp.132-33.

[5] Career and biological age cross-tabulations for behavioral scientists are contained in the appendix.

Table 1. Career Age and Biological Age Distribution of Biomedical Scientists, 1983-1987

| | Career Age | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Bio Age | <=5 | 6-10 | 11-15 | 16-20 | 21-25 | 26-30 | 31-35 | 36-40 | >=41 | Total |
| <30 | 1918 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1939 |
| 30-34 | 9463 | 4650 | 43 | 0 | 0 | 0 | 0 | 0 | 0 | 14156 |
| 35-39 | 3748 | 8547 | 4908 | 8 | 0 | 0 | 0 | 0 | 0 | 17211 |
| 40-44 | 977 | 3298 | 8618 | 5161 | 0 | 0 | 0 | 0 | 0 | 18054 |
| 45-49 | 280 | 678 | 2535 | 6340 | 2357 | 57 | 0 | 0 | 0 | 12247 |
| 50-54 | 124 | 204 | 907 | 2084 | 2943 | 1151 | 0 | 0 | 0 | 7413 |
| 55-59 | 81 | 101 | 274 | 744 | 1330 | 2037 | 1228 | 77 | 0 | 5872 |
| 60-64 | 3 | 61 | 77 | 181 | 511 | 1048 | 1702 | 474 | 6 | 4063 |
| 65-69 | 10 | 0 | 16 | 84 | 91 | 95 | 376 | 566 | 219 | 1457 |
| >=70 | 0 | 0 | 8 | 0 | 13 | 22 | 57 | 174 | 88 | 362 |
| Total | 16604 | 17560 | 17386 | 14602 | 7245 | 4410 | 3363 | 1291 | 313 | 82774 |

Relative Distribution

| | Career Age | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Bio Age | <=5 | 6-10 | 11-15 | 16-20 | 21-25 | 26-30 | 31-35 | 36-40 | >=41 |
| <30 | 0.1155 | 0.0011 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30-34 | 0.5699 | 0.2648 | 0.0024 | 0 | 0 | 0 | 0 | 0 | 0 |
| 35-39 | 0.2257 | 0.4867 | 0.2822 | 0.0005 | 0 | 0 | 0 | 0 | 0 |
| 40-44 | 0.0588 | 0.1878 | 0.4956 | 0.3534 | 0 | 0 | 0 | 0 | 0 |
| 45-49 | 0.0168 | 0.0386 | 0.1458 | 0.4341 | 0.3253 | 0.0129 | 0 | 0 | 0 |
| 50-54 | 0.0074 | 0.0116 | 0.0521 | 0.1427 | 0.4062 | 0.2609 | 0 | 0 | 0 |
| 55-59 | 0.0048 | 0.0057 | 0.0157 | 0.0509 | 0.1835 | 0.4619 | 0.3651 | 0.0596 | 0 |
| 60-64 | 0.0001 | 0.0034 | 0.0044 | 0.0123 | 0.0705 | 0.2376 | 0.5060 | 0.3671 | 0.0191 |
| 65-69 | 0.0006 | 0 | 0.0009 | 0.0057 | 0.0125 | 0.0215 | 0.1118 | 0.4384 | 0.6996 |
| >=70 | 0 | 0 | 0.0004 | 0 | 0.0017 | 0.0049 | 0.0169 | 0.1347 | 0.2811 |
| Total | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

SOURCE: 1983, 1985 and 1987, Survey of Doctorate Recipients, NRC.

Table 2. Death and Retirement Rates

| Bio Age | Retire Rate | Death Rate |
|---|---|---|
| <30 | 0 | 0.0011 |
| 30-34 | 0 | 0.0017 |
| 35-39 | 0 | 0.0027 |
| 40-44 | 0 | 0.0038 |
| 45-49 | 0 | 0.0063 |
| 50-54 | 0 | 0.0114 |
| 55-59 | 0.0026 | 0.0179 |
| 60-64 | 0.0753 | 0.0271 |
| 65-69 | 0.1714 | 0.0378 |
| >=70 | 1 | 0.05 |

SOURCE: Charlotte V. Kuh and Roy Radner, Mathematicians in Academia: 1975-2000, A Report to the National Science Foundation, Washington, D.C.: Conference Board of the Mathematical Sciences, 1980, pp. 84-86.

## Death and Retirement Rates

Table 2 contains estimates of death and retirement rates. These rates are for academicians *in toto*.

## Net Mobility Rates

Conceptually, the net outmobility rates of scientists are simply the gross occupational exits minus the gross occupational entrants by career age. Practically, these longitudinal movements are extremely difficult to measure given existing data sets. Therefore, a shortcut method based upon a cross-section of scientists by career age was used[6] to estimate these movements. As shown in Table 3 the values of each cell are the sum of SDR survey years 1983, 1985, and 1987. For example, the number of biomedical scientists of $C_{<=5} = 31{,}538$: $C_{<=5}$ for 1987 (10,823) + $C_{<=5}$ for 1985 (10,720) + $C_{<=5}$ for 1983 (9,995). Putting aside the debate of whether postdoctorates are students or employed and counting them as employed, the total pool of biomedical scientists $C_{<=5}$ is 48,847 (31,538 + 17,309). The total number of Ph.D.s in all fields except humanities and engineering with $C_{<=5}$ is 202,517; this is assumed to be the primary supply source for biomedical scientists. Because these estimates are for attrition other than death and retirement, all scientists who will retire must be removed from the labor supply pool (column 6, Table 3), giving a labor supply pool of 202,378 for $C_{<=5}$. Thus, for every 1,000 scientists of $C_{<=5}$, 241 are biomedical scientists [(31538 + 17309)/(202378)]. For every 1,000 scientists of $C_{6-10}$, 231 are biomedical scientists. Assuming that this cross-section reflects the longitudinal movement of scientists, then the net outmobility rate of $C_{<=6}$ is 4.1 percent [(241-231)/241). This rate is for a five-year period and must be annualized: assuming that the average time of transition for a given scientist $C_{<=6}$ to $C_{6-10}$ is 2.5 years, then the annualized net outmobility rate is 1.79 percent (i.e., 98.21 percent of biomedical scientists of $C_{<=6}$ "survive" into the next year, while 1.79 percent move into nonbiomedical fields).[7]

## Model Structure

Given the above parameters, the operation of the model is fairly straightforward. At a point in time *t*, a group of scientists S are identified by their career age C. Death and retirement are estimated from this group by the following equation:

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[6] This shortcut method was suggested by Robert Dauffenbach, a member of the Committee on Biomedical and Behavioral Research Personnel.

[7] Of course, this survival rate is the difference between larger gross outmobility and gross immobility.

$$(1)\quad P(DR_r) = \quad \Sigma(n)\quad P(B_n|C_r)*P(DR_n|B_n)$$

Where

$P(DR_r)$ = the probability of death or retirement given career age r;

$P(B_n|C_r)$ = the probability of biological age = n given career age = r;

$P(DR_n|B_n)$ = the probability of death or retirement given biological age = n;

and $\Sigma(n)$ sums these probabilities across all biological ages n.

Given that an individual does not retire or die, he or she can now leave the biomedical work force for other occupations. The total attrition rate for career age = r is thus:

$$(2)\quad P(A_r) = \quad P(OM_r)*[1-P(DR_r)]$$

where

$P(A_r)$ = conditional probability of total attrition given career age r;

$P(OM_r)$ = simple probability of net outmobility for career age = r

$[1-P(DR_r)]$ = probability of *not* retiring or dying given career age r;

. . . the total attrition estimate for all employed biomedical scientists is:

$$(3)\quad TA = \quad \Sigma(r)\quad S_r*P(A_r)$$

where

TA = total attrition from death, retirement, and net outmobility and

$S_r$ = the number of scientists career age r.

Thus, for each group of scientists career age r, the estimated attrition leaves a surviving group of scientists in period t+1 that moves to the next career age r+1. Summing across all career ages gives the total attrition for the stock of scientists S and allows for the computation of the total surviving scientists in period *t+1* (Figure 1).

## DEMAND FOR SCIENTISTS

As shown in Figure 1, the demand for scientists is derived from the services that they produce--for example, R&D and teaching graduate students. Other factors, in particular wage rates, can also affect the level of scientist demand. The demand models used in this analysis--simple forms of this conceptual model[8] estimated for each field (biomedical and behavioral), sector (academic, industrial, hospital,) and work activity (R&D and non-R&D)--are included in the Appendix. Table 4 contains the detailed projections for biomedical scientists; the Appendix contains the detailed tables for nonclinical psychologists and other behavioral scientists. The projection model assumptions were developed by the Committee on Biomedical and Behavioral Research Personnel.

Table 3. Estimated Quit Rates for Biomedical Scientists, 1983-1987

| Career Age | (1) Biomed | (2) Biomed R&D & Mgt R&D | (3) Postdoc Biomed | (4) Retired | (5) Total Ph.D.s | (6) Total Ph.D.s -retire | (7) Bio Sci per 1000 Sci | (8) Annual Quit Rate | (9) Annual R&D Quit Rate |
|---|---|---|---|---|---|---|---|---|---|
| <=5 | 31538 | 19695 | 17309 | 139 | 202517 | 202378 | 241 | | |
| 6-10 | 48171 | 29975 | 2419 | 373 | 219649 | 219276 | 231 | -1.79% | -8.18% |
| 11-15 | 49162 | 26230 | 531 | 990 | 216355 | 215365 | 231 | 0.00% | -6.69% |
| 16-20 | 34190 | 16674 | 135 | 2279 | 156309 | 154030 | 223 | -1.38% | -5.06% |
| 21-25 | 18257 | 8406 | 24 | 4041 | 90762 | 86721 | 211 | -2.20% | -4.52% |
| 26-30 | 12726 | 5383 | 36 | 6428 | 66917 | 60489 | 211 | 0.03% | -3.21% |
| 31-35 | 8567 | 3790 | 24 | 13162 | 55630 | 42468 | 202 | -1.67% | 0.10% |
| 36-40 | 2743 | 1095 | 7 | 11772 | 26291 | 14519 | 189 | -2.60% | -6.51% |
| 41+ | 1295 | 495 | 0 | 6507 | 11286 | 4779 | 271 | 15.40% | 13.24% |
| Total | 206649 | 111743 | 20485 | 45691 | 1045716 | 1000025 | | | |
| | | | | | Average annual quit rate | | | -0.8% | |

SOURCE: 1983, 1985, and 1987 Survey of Doctorate Recipients, National Research Council.

### Postdoctorates

There are no explicit projections for postdoctorates. The level of postdoctorate employment is assumed to be an institutional variable determined by public policy and, as a simplifying assumption, the level of postdoctorate employment was held constant during the time frame of analysis. Thus, the level of postdoctoral employment does not affect the level of total employment; and given that most postdoctorates are young, very little labor supply is assumed to be lost from death, retirement, or outmobility.

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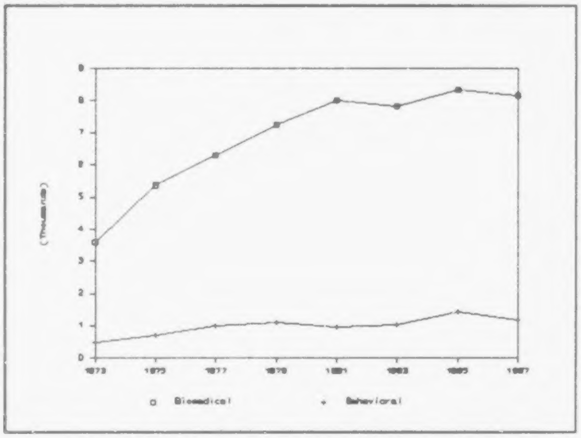
[8] For a model of biomedical scientist demand that includes factor prices in both the demand and supply equations, see Joe G. Baker, "The Ph.D. Supply Crisis: A Look at the Biomedical Sciences," paper given at the June 21, 1989, Western Economics Association Meeting, Lake Tahoe, Nevada. It should be noted that the inclusion of factor prices did not change the salient results of the analysis.

If the postdoctorate "pool" is assumed constant with little or no attrition, then one can further assume that the annual exits from this pool equal entrants, and the net effect on labor supply to positions outside the pool is small. If the pool is changing in size, then entrants and exits will not be equal. As can be seen in Figure 2, the postdoctoral pool has been flat since 1981 at approximately 8,100 biomedical scientists. In the behavioral sciences, postdoctoral employment has been flat since 1979 at approximately 1,100 scientists.



SOURCE: Survey of Doctorate Recipients.

**Figure 2.** Postdoctoral Employment in Biomedical and Behavioral Sciences, 1973-1987

**Analysis: Vacancy Ratios**

The model discussed above estimates annual job openings from death, retirement, net outmobility, and growth. As a means to summarize the relationship between these job openings and labor supply and to provide information about the future labor market, the concept of "vacancy ratios" was developed. Simply put, the vacancy ratio is the average number of job openings per new Ph.D. For the period 1983-1987, the number of job openings from death, retirement and growth averaged 4846 annually (Table 5). The average number of new Ph.D.s in the biomedical sciences produced annually for this same period was 3862. Thus, the "vacancy ratio" was 1.25 openings per each new Ph.D. An "R&D vacancy ratio" is calculated by comparing R&D job openings to postdoctorate production.

Obviously, not all new Ph.D.s in biomedical science go into the biomedical field; also the field draws Ph.D.s from other areas (e.g., physical sciences and other life sciences) including foreign scientists. However, the primary source of new Ph.D.s is U.S. graduates in the field and, thus, the vacancy ratio gives one a sense of the historical relationship between this supply source and demand. No value judgments are made in terms of what the "correct" vacancy ratio is; the projected vacancy ratios simply provide information about the relative state of the labor market under differing assumptions.

Table 4. Summary Projections in Biomedical Sciences

Biomedical Sensitivity Model

| Model Assumptions | High | Mid | Low |
|---|---|---|---|
| 1. Federal Health R&D Funding Growth | 4.0% | 2.7% | 0.2% |
| 2. Private Health R&D Funding Growth | 13.0% | 9.0% | 5.0% |
| 3. Other Health R&D Funding Growth | 4.0% | 3.0% | 2.0% |
| 4. Grad and Undergrad Biomed Enrollment | 1.0% | 0.0% | -1.0% |
| 5. "Other" biomed R&D Employment Growth | 3.5% | 2.5% | 1.5% |
| 6. "Other" biomed non-R&D Employment Growth | 10.0% | 8.0% | 5.0% |

Projected Employment of Biomedical Scientists, 1973-2000
(in 100s of workers)

| | Low Case | | | Mid Case | | | High Case | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Total | R&D | % R&D | Total | R&D | % R&D | Total | R&D | % R&D |
| 1973 | 396.4 | 197.8 | 49.9% | 396.4 | 197.8 | 49.9% | 396.4 | 197.8 | 49.9% |
| 1975 | 447.2 | 211.8 | 47.4% | 447.2 | 211.8 | 47.4% | 447.2 | 211.8 | 47.4% |
| 1977 | 479.2 | 237.9 | 49.6% | 479.2 | 237.9 | 49.6% | 479.2 | 237.9 | 49.6% |
| 1979 | 543.8 | 284.5 | 52.3% | 543.8 | 284.5 | 52.3% | 543.8 | 284.5 | 52.3% |
| 1981 | 600.1 | 316.2 | 52.7% | 600.1 | 316.2 | 52.7% | 600.1 | 316.2 | 52.7% |
| 1983 | 626.4 | 322.1 | 51.4% | 626.4 | 322.1 | 51.4% | 626.4 | 322.1 | 51.4% |
| 1985 | 703.2 | 366.7 | 52.1% | 703.2 | 366.7 | 52.1% | 703.2 | 366.7 | 52.1% |
| 1987 | 762.6 | 437.6 | 57.4% | 762.6 | 437.6 | 57.4% | 762.6 | 437.6 | 57.4% |
| 1988 | 786.4 | 451.2 | 57.4% | 802.4 | 464.0 | 57.8% | 816.6 | 475.3 | 58.2% |
| 1989 | 791.6 | 459.0 | 58.0% | 823.3 | 484.1 | 58.8% | 851.6 | 506.5 | 59.5% |
| 1990 | 811.1 | 466.8 | 57.6% | 858.7 | 504.2 | 58.7% | 901.7 | 538.1 | 59.7% |
| 1991 | 825.0 | 474.6 | 57.5% | 888.8 | 524.4 | 59.0% | 947.8 | 570.9 | 60.2% |
| 1992 | 839.3 | 482.4 | 57.5% | 919.9 | 545.2 | 59.3% | 996.8 | 605.9 | 60.8% |
| 1993 | 855.2 | 490.4 | 57.3% | 953.6 | 566.9 | 59.4% | 1050.7 | 643.9 | 61.3% |
| 1994 | 869.6 | 498.5 | 57.3% | 987.2 | 589.8 | 59.7% | 1107.5 | 685.7 | 61.9% |
| 1995 | 886.5 | 506.8 | 57.2% | 1024.6 | 614.1 | 59.9% | 1171.5 | 732.1 | 62.5% |
| 1996 | 894.9 | 515.4 | 57.6% | 1055.3 | 640.1 | 60.6% | 1232.7 | 783.7 | 63.6% |
| 1997 | 913.2 | 524.3 | 57.4% | 1097.9 | 668.1 | 60.8% | 1310.3 | 841.4 | 64.2% |
| 1998 | 928.8 | 533.5 | 57.4% | 1140.0 | 698.3 | 61.3% | 1392.5 | 906.0 | 65.1% |
| 1999 | 947.4 | 543.1 | 57.3% | 1187.7 | 731.0 | 61.6% | 1486.0 | 978.4 | 65.8% |
| 2000 | 973.6 | 553.1 | 56.8% | 1245.6 | 766.5 | 61.5% | 1596.4 | 1059.6 | 66.4% |
| Growth Rates: | | | | | | | | | |
| 73-87 | 4.8% | 5.8% | | 4.8% | 5.8% | | 4.8% | 5.8% | |
| 87-91 | 2.0% | 2.0% | | 3.9% | 4.6% | | 5.6% | 6.9% | |
| 87-20 | 1.9% | 1.8% | | 3.8% | 4.4% | | 5.8% | 7.0% | |

NOTE: This table does not include postdoctoral employment or unemployment.
SOURCE: Estimated by National Research Council.

Table 4. (continued) Projections of Biomedical Employment by Sector, 1987-2000
(Workers in 100s)

| Sector | 1987 | | | 1991 | | | 2000 | | | 87-91 Growth | | 87-20 Growth | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | R&D | % R&D | Total | R&D | % R&D | Total | R&D | % R&D | Total | R&D | Total | R&D |
| Academic | | | | | | | | | | | | | |
| Low Case | 430.3 | 227.5 | 52.9% | 435.3 | 235.6 | 54.1% | 408.5 | 226.1 | 55.4% | 0.3% | 0.9% | -0.4% | 0.0% |
| Medium Case | 430.3 | 227.5 | 52.9% | 461.5 | 253.6 | 55.0% | 468.7 | 260.8 | 55.7% | 1.8% | 2.8% | 0.7% | 1.1% |
| High Case | 430.3 | 227.5 | 52.9% | 484.3 | 268.0 | 55.3% | 533.5 | 297.0 | 55.7% | 3.0% | 4.2% | 1.7% | 2.1% |
| Industrial | | | | | | | | | | | | | |
| Low Case | 185.6 | 126.9 | 68.3% | 229.8 | 153.1 | 66.6% | 366.0 | 234.8 | 64.1% | 5.5% | 4.8% | 5.4% | 4.8% |
| Medium Case | 185.6 | 126.9 | 68.3% | 253.7 | 177.0 | 69.8% | 509.8 | 378.6 | 74.3% | 8.1% | 8.7% | 8.1% | 8.8% |
| High Case | 185.6 | 126.9 | 68.3% | 280.4 | 203.7 | 72.6% | 733.1 | 601.8 | 82.1% | 10.9% | 12.6% | 11.1% | 12.7% |
| Government | | | | | | | | | | | | | |
| Low Case | 70.5 | 46.7 | 66.2% | 72.9 | 47.0 | 64.5% | 79.9 | 47.8 | 59.9% | 0.8% | 0.2% | 1.0% | 0.2% |
| Medium Case | 70.5 | 46.7 | 66.2% | 79.3 | 53.4 | 67.4% | 108.7 | 76.7 | 70.5% | 3.0% | 3.4% | 3.4% | 3.9% |
| High Case | 70.5 | 46.7 | 66.2% | 83.1 | 57.2 | 68.9% | 135.7 | 103.6 | 76.4% | 4.2% | 5.2% | 5.2% | 6.3% |
| All Other Biomedical | | | | | | | | | | | | | |
| Low Case | 76.3 | 36 6 | 47.9% | 87.1 | 38.8 | 44.6% | 119.2 | 44.4 | 37.2% | 3.4% | 1.5% | 3.5% | 1.5% |
| Medium Case | 76.3 | 36.6 | 47.9% | 94.4 | 40.4 | 42.8% | 158.4 | 50.4 | 31.8% | 5.5% | 2.5% | 5.8% | 2.5% |
| High Case | 76.3 | 36.6 | 47.9% | 100.1 | 42.0 | 41.9% | 194.2 | 57.2 | 29.4% | 7.0% | 3.5% | 7.5% | 3.5% |
| Total | | | | | | | | | | | | | |
| Low Case | 762.6 | 437.6 | 57.4% | 825.0 | 474.6 | 57.5% | 973.6 | 553.1 | 56.8% | 2.0% | 2.0% | 1.9% | 1.8% |
| Medium Case | 762.6 | 437.6 | 57.4% | 888.8 | 524.4 | 59.0% | 1245.6 | 766.5 | 61.5% | 3.9% | 4.6% | 3.8% | 4.4% |
| High Case | 762.6 | 437.6 | 57.4% | 947.8 | 570.9 | 60.2% | 1596.4 | 1059.6 | 66.4% | 5.6% | 6.9% | 5.8% | 7.0% |

NOTE: Excludes postdocs and unemployed.

SOURCE: Projections by NRC.

Table 5. Historical and Projected Vacancy Ratios, Biomedical Sciences, 1973-2000

| | Annual Averages | | | | | |
|---|---|---|---|---|---|---|
| | Total | | | R&D | | |
| Year | Vacancies | Ph.D.s | Ratio | Vacancies | Post-docs | Ratio |
| 1973-78 | 3455 | 3499 | 0.99 | 2344 | 2868 | 0.82 |
| 1978-83 | 3957 | 3763 | 1.05 | 2863 | 3788 | 0.76 |
| 1983-87 | 4846 | 3862 | 1.25 | 4157 | 4072 | 1.02 |
| 1987-95 | | | | | | |
| Low | 4047 | 3662 | 1.11 | 3086 | 3900 | 0.79 |
| Mid | 5955 | 3969 | 1.50 | 4626 | 3900 | 1.19 |
| High | 8063 | 4298 | 1.88 | 6386 | 3900 | 1.64 |

NOTE: Assumes that Ph.D. production changes in proportion to enrollment assumptions and postdoctoral production remains constant.

SOURCE: National Research Council.

## BIOMEDICAL PH.D. R&D PROJECTION MODEL

### Mid Case R&D

| Bio Age | Projected Years 1987 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 2000 | Growth Rates (base = 1987) 1991 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| <30 | 1025 | 1903 | 2173 | 2453 | 2426 | 2489 | 2572 | 3282 | 20.7% | 12.2% | 9.4% |
| 30-34 | 7484 | 11520 | 12769 | 14065 | 14597 | 15419 | 16344 | 21127 | 14.3% | 10.3% | 8.3% |
| 35-39 | 9099 | 10019 | 10312 | 10635 | 11730 | 12725 | 13766 | 18926 | 3.2% | 5.3% | 5.8% |
| 40-44 | 9545 | 9297 | 9227 | 9173 | 9383 | 9546 | 9733 | 13053 | -0.8% | 0.2% | 2.4% |
| 45-49 | 6475 | 6846 | 6941 | 7026 | 6958 | 6888 | 6828 | 7126 | 1.8% | 0.7% | 0.7% |
| 50-54 | 3919 | 4545 | 4708 | 4852 | 4921 | 4975 | 5020 | 5062 | 4.7% | 3.1% | 2.0% |
| 55-59 | 3104 | 3368 | 3437 | 3497 | 3698 | 3868 | 4009 | 4407 | 2.6% | 3.2% | 2.7% |
| 60-64 | 2148 | 2116 | 2102 | 2085 | 2212 | 2313 | 2392 | 2821 | -0.5% | 1.4% | 2.1% |
| 65-69 | 770 | 657 | 630 | 603 | 626 | 621 | 614 | 697 | -4.9% | -2.8% | -0.8% |
| >=70 | 191 | 150 | 140 | 131 | 139 | 136 | 132 | 148 | -7.5% | -4.5% | -2.0% |
| Total | 43760 | 50420 | 52440 | 54520 | 56690 | 58980 | 61410 | 76650 | 4.6% | 4.3% | 4.4% |

Percent Distribution

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| <30 | 2.3% | 3.8% | 4.1% | 4.5% | 4.3% | 4.2% | 4.2% | 4.3% |
| 30-34 | 17.1% | 22.8% | 24.3% | 25.8% | 25.7% | 26.1% | 26.6% | 27.6% |
| 35-39 | 20.8% | 19.9% | 19.7% | 19.5% | 20.7% | 21.6% | 22.4% | 24.7% |
| 40-44 | 21.8% | 18.4% | 17.6% | 16.8% | 16.6% | 16.2% | 15.8% | 17.0% |
| 45-49 | 14.8% | 13.6% | 13.2% | 12.9% | 12.3% | 11.7% | 11.1% | 9.3% |
| 50-54 | 9.0% | 9.0% | 9.0% | 8.9% | 8.7% | 8.4% | 8.2% | 6.6% |
| 55-59 | 7.1% | 6.7% | 6.6% | 6.4% | 6.5% | 6.6% | 6.5% | 5.7% |
| 60-64 | 4.9% | 4.2% | 4.0% | 3.8% | 3.9% | 3.9% | 3.9% | 3.7% |
| 65-69 | 1.8% | 1.3% | 1.2% | 1.1% | 1.1% | 1.1% | 1.0% | 0.9% |
| >=70 | 0.4% | 0.3% | 0.3% | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% |
| =>55 | 14.2% | 12.5% | 12.0% | 11.6% | 11.8% | 11.8% | 11.6% | 10.5% |

Mean Biological Age

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 43.7 | 42.5 | 42.2 | 41.9 | 41.8 | 41.7 | 41.5 | 40.9 |

| Total Vacancies | | | | | | | | Average Annual Vacancies (base = 1990) 1991 | 1995 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|
| D&R | 804 | 782 | 764 | 748 | 798 | 808 | 910 | 793 | 784 | 857 |
| Quits | 1529 | 1586 | 1642 | 1699 | 1765 | 1833 | 2247 | 1557 | 1675 | 1888 |
| Growth | 2010 | 2020 | 2080 | 2170 | 2290 | 2430 | 3550 | 2015 | 2167 | 2780 |
| Total | 4343 | 4388 | 4486 | 4617 | 4852 | 5071 | 6707 | 4365 | 4626 | 5525 |

| Attrition Rates | | | | | | | |
|---|---|---|---|---|---|---|---|
| D&R | 1.7% | 1.6% | 1.5% | 1.4% | 1.4% | 1.4% | 1.2% |
| Quits | 3.2% | 3.1% | 3.1% | 3.1% | 3.1% | 3.1% | 3.1% |
| Total | 4.8% | 4.7% | 4.6% | 4.5% | 4.5% | 4.5% | 4.3% |

## BIOMEDICAL PHD PROJECTION MODEL

### Mid Case

| Bio Age | Projected Years | | | | | | | | Growth Rates (base = 1987) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1987 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 2000 | 1991 | 1995 | 2000 |
| <30 | 1786 | 2577 | 2831 | 3105 | 3073 | 3257 | 3337 | 4223 | 12.2% | 8.1% | 6.8% |
| 30-34 | 13042 | 16684 | 17830 | 19061 | 19605 | 20793 | 21827 | 27810 | 8.1% | 6.6% | 6.0% |
| 35-39 | 15857 | 16777 | 17050 | 17353 | 18531 | 19326 | 20579 | 26777 | 1.8% | 3.3% | 4.1% |
| 40-44 | 16633 | 16735 | 16808 | 16910 | 17197 | 17283 | 17571 | 21448 | 0.3% | 0.7% | 2.0% |
| 45-49 | 11283 | 12522 | 12910 | 13290 | 13307 | 13312 | 13373 | 14089 | 3.4% | 2.1% | 1.7% |
| 50-54 | 6830 | 8441 | 8926 | 9386 | 9683 | 9957 | 10223 | 10890 | 6.9% | 5.2% | 3.7% |
| 55-59 | 5410 | 6323 | 6615 | 6898 | 7478 | 8001 | 8474 | 10162 | 5.2% | 5.8% | 5.0% |
| 60-64 | 3743 | 4088 | 4188 | 4280 | 4635 | 4949 | 5235 | 6873 | 2.8% | 4.3% | 4.8% |
| 65-69 | 1342 | 1389 | 1390 | 1381 | 1488 | 1489 | 1491 | 1867 | 0.9% | 1.3% | 2.6% |
| >=70 | 334 | 335 | 332 | 326 | 361 | 354 | 349 | 422 | -0.1% | 0.6% | 1.8% |
| Total | 76260 | 85870 | 88880 | 91990 | 95360 | 98720 | 102460 | 124560 | 3.9% | 3.8% | 3.8% |

Percent Distribution

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| <30 | 2.3% | 3.0% | 3.2% | 3.4% | 3.2% | 3.3% | 3.3% | 3.4% |
| 30-34 | 17.1% | 19.4% | 20.1% | 20.7% | 20.6% | 21.1% | 21.3% | 22.3% |
| 35-39 | 20.8% | 19.5% | 19.2% | 18.9% | 19.4% | 19.6% | 20.1% | 21.5% |
| 40-44 | 21.8% | 19.5% | 18.9% | 18.4% | 18.0% | 17.5% | 17.1% | 17.2% |
| 45-49 | 14.8% | 14.6% | 14.5% | 14.4% | 14.0% | 13.5% | 13.1% | 11.3% |
| 50-54 | 9.0% | 9.8% | 10.0% | 10.2% | 10.2% | 10.1% | 10.0% | 8.7% |
| 55-59 | 7.1% | 7.4% | 7.4% | 7.5% | 7.8% | 8.1% | 8.3% | 8.2% |
| 60-64 | 4.9% | 4.8% | 4.7% | 4.7% | 4.9% | 5.0% | 5.1% | 5.5% |
| 65-69 | 1.8% | 1.6% | 1.6% | 1.5% | 1.6% | 1.5% | 1.5% | 1.5% |
| >=70 | 0.4% | 0.4% | 0.4% | 0.4% | 0.4% | 0.4% | 0.3% | 0.3% |
| =>55 | 14.2% | 14.1% | 14.1% | 14.0% | 14.6% | 15.0% | 15.2% | 15.5% |

Mean Biological Age

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 43.7 | 43.4 | 43.3 | 43.3 | 43.4 | 43.3 | 43.3 | 42.9 |

| Total Vacancies | | | | | | | | Average Annual Vacancies (base = 1990) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 1991 | 1995 | 2000 |
| D&R | 1564 | 1582 | 1593 | 1601 | 1788 | 1816 | 2154 | 1573 | 1657 | 1859 |
| Quits | 837 | 883 | 927 | 977 | 994 | 1040 | 1230 | 860 | 943 | 1034 |
| Growth | 3540 | 3010 | 3110 | 3370 | 3360 | 3740 | 5790 | 3275 | 3355 | 4665 |
| Total | 5941 | 5475 | 5630 | 5948 | 6142 | 6596 | 9174 | 5708 | 5955 | 7558 |

| Attrition Rates | | | | | | | |
|---|---|---|---|---|---|---|---|
| D&R | 1.9% | 1.8% | 1.8% | 1.7% | 1.9% | 1.8% | 1.8% |
| Quits | 1.0% | 1.0% | 1.0% | 1.1% | 1.0% | 1.1% | 1.0% |
| Total | 2.9% | 2.9% | 2.8% | 2.8% | 2.9% | 2.9% | 2.8% |

# APPENDIX

Table A-1. Academic Projection Models Biomedical Sciences

| | Employment | | | | Projected | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Total | Non-R&D | R&D | R&D$ | Wgt Enrll | Total Fac. | R&D | Non-R&D | % R&D |
| Assumption | | | 3.0% | 0.0% | | | | | |
| 73 | 25471 | 15556 | 9915 | 1184.3 | 158698 | 23609 | 9190 | 14419 | 38.9 |
| 75 | 28332 | 18040 | 10292 | 1192.6 | 180485 | 27048 | 9825 | 17223 | 36.3 |
| 77 | 30384 | 17861 | 12523 | 1269 | 195353 | 31259 | 12884 | 18375 | 41.2 |
| 79 | 33566 | 18551 | 15015 | 1346.9 | 197091 | 33545 | 15006 | 18539 | 44.7 |
| 81 | 36482 | 19854 | 16628 | 1488.3 | 191996 | 35974 | 16397 | 19577 | 45.6 |
| 83 | 36963 | 20053 | 16910 | 1571.3 | 190546 | 37403 | 17111 | 20291 | 45.7 |
| 85 | 41032 | 21425 | 19607 | 1828.6 | 190291 | 41439 | 19802 | 21637 | 47.8 |
| 87 | 43025 | 20274 | 22751 | 2142.3 | 189218 | 44106 | 23323 | 20783 | 52.9 |
| 88 | | | | 2206.5 | 189218 | 44495 | 23712 | 20783 | 53.3 |
| 89 | | | | 2272.7 | 189218 | 44841 | 24058 | 20783 | 53.7 |
| 90 | | | | 2340.9 | 189218 | 45147 | 24364 | 20783 | 54.0 |
| 91 | | | | 2411.1 | 189218 | 45416 | 24633 | 20783 | 54.2 |
| 92 | | | | 2483.5 | 189218 | 45650 | 24867 | 20783 | 54.5 |
| 93 | | | | 2558.0 | 189218 | 45852 | 25069 | 20783 | 54.7 |
| 94 | | | | 2634.7 | 189218 | 46027 | 25244 | 20783 | 54.8 |
| 95 | | | | 2713.8 | 189218 | 46176 | 25393 | 20783 | 55.0 |
| 96 | | | | 2795.2 | 189218 | 46302 | 25519 | 20783 | 55.1 |
| 97 | | | | 2879.0 | 189218 | 46409 | 25626 | 20783 | 55.2 |
| 98 | | | | 2965.4 | 189218 | 46498 | 25715 | 20783 | 55.3 |
| 99 | | | | 3054.4 | 189218 | 46572 | 25789 | 20783 | 55.4 |
| 100 | | | | 3146.0 | 189218 | 46634 | 25851 | 20783 | 55.4 |

NOTE: The Academic Projection Model uses the Singer model and assumes the following:

1. The non-R&D faculty to student ratio (.1098 in 1987) will remain constant through projection period; therefore taking .1098 of wgt. enrollment gives non-R&D employment.
2. R&D faculty employment is simply total-non-R&D.
3. The Singer model is used to project total faculty employment:

$$F/WS = (K-C)\exp(-e^{(a-bM)})+C$$

N= 10
Std Er= .00580
$R^2$= .965

Where K and C are scaling constants
a,b are model parameters
M= biomedical R&D expenditures
F= biomedical faculty
WS= .25*(undergrads)+.75*(grad students)

| Coef. | Est. | Std.Er. | t |
|---|---|---|---|
| a | 2.391 | 2.6316 | 0.9085 |
| b | 0.0019 | 0.0024 | 0.8182 |
| C | 0.1005 | 0.0454 | 2.2121 |
| K | 0.2519 | 0.1607 | 1.5674 |

Table A-2. Industrial Projection Models, Biomedical Sciences

| | | Employment | | | | Projected | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Total | Non-R&D | R&D | Priv R&D$ | BLS DRG Outp | Total Ind | R&D | Non-R&D | % R&D |
| Assumption | | | | 4.0% | | | | | |
| 73 | 5887 | 1757 | 4130 | 991 | 165.3 | 6340 | 4657 | 1682 | 73.5 |
| 75 | 7502 | 2501 | 5001 | 1037 | 178.4 | 7081 | 4860 | 2221 | 68.6 |
| 77 | 7755 | 2626 | 5129 | 1139 | 203.8 | 8575 | 5309 | 3266 | 61.9 |
| 79 | 9633 | 3276 | 6357 | 1265 | 218.1 | 9718 | 5863 | 3854 | 60.3 |
| 81 | 11785 | 4463 | 7322 | 1497 | 230.0 | 11228 | 6885 | 4344 | 61.3 |
| 83 | 13729 | 5239 | 8490 | 1871 | 245.8 | 13525 | 8531 | 4994 | 63.1 |
| 85 | 15960 | 6296 | 9664 | 2249 | 250.9 | 15398 | 10195 | 5203 | 66.2 |
| 87 | 18562 | 5875 | 12687 | 2768 | 281.8 | 18954 | 12480 | 6474 | 65.8 |
| 88 | | | | 2879 | 293.1 | 19514 | 13174 | 6340 | 67.5 |
| 89 | | | | 2994 | 287.4 | 19787 | 13681 | 6105 | 69.1 |
| 90 | | | | 3114 | 312.7 | 21354 | 14208 | 7146 | 66.5 |
| 91 | | | | 3238 | 325.4 | 22425 | 14757 | 7668 | 65.8 |
| 92 | | | | 3368 | 338.5 | 23534 | 15327 | 8207 | 65.1 |
| 93 | | | | 3502 | 354.7 | 24794 | 15920 | 8874 | 64.2 |
| 94 | | | | 3642 | 367.0 | 25916 | 16537 | 9380 | 63.8 |
| 95 | | | | 3788 | 383.9 | 27253 | 17178 | 10075 | 63.0 |
| 96 | | | | 3940 | 381.2 | 27809 | 17845 | 9964 | 64.2 |
| 97 | | | | 4097 | 399.2 | 29243 | 18539 | 10704 | 63.4 |
| 98 | | | | 4261 | 410.2 | 30417 | 19260 | 11157 | 63.3 |
| 99 | | | | 4432 | 426.6 | 31842 | 20011 | 11831 | 62.8 |
| 100 | | | | 4609 | 458.0 | 33914 | 20791 | 13123 | 61.3 |

NOTE: The Industrial Projection Model uses an R&D and output model and assumes the following:

1. Industrial biomedical R&D employment is a function of private R&D expenditures as per regression Equation 1. This equation coefficient was applied to change in Priv R&D$ to determine projected employment.

2. Industrial biomedical non-R&D employment is a function of drug industry constant dollar output as per Equation 2. This equation coefficient was applied to change in BLS drug output to determine projected employment.

EQUATION 1

(R&Demp)=f(R&D$)

Regression Output:

| | |
|---|---|
| Constant | 294.76 |
| Std Err of Y Est | 426.51 |
| R Squared | 0.9808 |
| No. of Observations | 8 |
| Degrees of Freedom | 6 |
| X Coefficient | 4.4021 |
| Standard Error of Coefficient | 0.2512 |

EQUATION 2

(non-R&Demp)=f(drgoutp)

Regression Output:

| | |
|---|---|
| Constant | -5117. |
| Std Err of Y Est | 639.62 |
| R Squared | 0.8786 |
| No. of Observations | 8 |
| Degrees of Freedom | 6 |
| X Coefficient | 41.133 |
| Standard Error of Coefficient | 6.2410 |

Table A-3. Government Projection Models, Biomedical Sciences

| | Employment | | | | BLS | | Projected | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Total | Non-R&D | R&D | Pub R&D$ | Gov Output | Total Gov | R&D | Non-R&D | % R&D |
| Assumption | | | | 2.7% | | | | | |
| 73 | 4338 | 1244 | 3094 | 2103 | 110.4 | 4479 | 2929 | 1550 | 65.4 |
| 75 | 4517 | 1410 | 3107 | 2226 | 109.6 | 4559 | 3071 | 1489 | 67.4 |
| 77 | 4568 | 1632 | 2936 | 2397 | 109.5 | 4760 | 3279 | 1481 | 68.9 |
| 79 | 5080 | 1759 | 3321 | 2612 | 111.0 | 5157 | 3561 | 1596 | 69.1 |
| 81 | 5398 | 1869 | 3529 | 2484 | 115.0 | 5292 | 3390 | 1902 | 64.1 |
| 83 | 5988 | 2380 | 3608 | 2504 | 119.0 | 5625 | 3416 | 2208 | 60.7 |
| 85 | 6479 | 2661 | 3818 | 2942 | 122.6 | 6526 | 4042 | 2484 | 61.9 |
| 87 | 7049 | 2379 | 4670 | 3120 | 124.5 | 6957 | 4328 | 2629 | 62.2 |
| 88 | | | | 3204 | 125.2 | 7256 | 4823 | 2433 | 66.5 |
| 89 | | | | 3291 | 124.8 | 7388 | 4986 | 2402 | 67.5 |
| 90 | | | | 3380 | 126.4 | 7684 | 5159 | 2524 | 67.1 |
| 91 | | | | 3471 | 127.2 | 7929 | 5343 | 2586 | 67.4 |
| 92 | | | | 3565 | 128.0 | 8186 | 5539 | 2647 | 67.7 |
| 93 | | | | 3661 | 128.9 | 8464 | 5748 | 2716 | 67.9 |
| 94 | | | | 3760 | 129.7 | 8747 | 5970 | 2777 | 68.3 |
| 95 | | | | 3861 | 130.7 | 9061 | 6207 | 2854 | 68.5 |
| 96 | | | | 3965 | 130.6 | 9307 | 6461 | 2846 | 69.4 |
| 97 | | | | 4072 | 131.7 | 9662 | 6732 | 2930 | 69.7 |
| 98 | | | | 4182 | 132.3 | 9998 | 7022 | 2976 | 70.2 |
| 99 | | | | 4295 | 133.3 | 10386 | 7333 | 3053 | 70.6 |
| 100 | | | | 4411 | 135.3 | 10873 | 7667 | 3206 | 70.5 |

NOTE: The Government Projection Model uses an R&D and output model and assumes the following:

1. Government biomed R&D Employment is a function of Federal R&D expenditures as per regression Equation 1. This equation coefficient was applied to change in Fed R&D$ to determine projected Employment.

2. Government biomed non-R&D Employment is a function of federal government constant dollar output as per Equation 2. This equation coefficient was applied to change in BLS government output to determine projected Employment.

| EQUATION 1 | |
|---|---|
| Ln(R&Demp)=F(fed R&D$) | |
| Regression Output: | |
| Constant | 7.1749 |
| Std Err of Y Est | 0.0751 |
| R Squared | 0.7803 |
| No. of Observations | 8 |
| Degrees of Freedom | 6 |
| X Coefficient | 0.0003 |
| Standard Error of Coefficient | 0.0000 |

| EQUATION 2 | |
|---|---|
| (Non-R&Demp)=F(fed output) | |
| Regression Output: | |
| Constant | -6903. |
| Std Err of Y Est | 213.73 |
| R Squared | 0.8477 |
| No. of Observations | 8 |
| Degrees of Freedom | 6 |
| X Coefficient | 76.565 |
| Standard Error of Coefficient | 13.248 |

Table A-4. All Other Employment, Biomedical Sciences

| | Employment | | | Projected | | | |
|---|---|---|---|---|---|---|---|
| Year | Total | Non-R&D | R&D | Total Other | R&D | Non-R&D | % R&D |
| Assumption | | | | | 2.5% | 8.0% | |
| 73 | 3941 | 1296 | 2645 | 3941 | 2645 | 1296 | 67.1 |
| 75 | 4368 | 1589 | 2779 | 4368 | 2779 | 1589 | 63.6 |
| 77 | 5215 | 2015 | 3200 | 5215 | 3200 | 2015 | 61.4 |
| 79 | 6102 | 2344 | 3758 | 6102 | 3758 | 2344 | 61.6 |
| 81 | 6348 | 2204 | 4144 | 6348 | 4144 | 2204 | 65.3 |
| 83 | 5964 | 2766 | 3198 | 5964 | 3198 | 2766 | 53.6 |
| 85 | 6852 | 3271 | 3581 | 6852 | 3581 | 3271 | 52.3 |
| 87 | 7626 | 3970 | 3656 | 7626 | 3656 | 3970 | 47.9 |
| 88 | 0.0482 | 0.0832 | 0.0233 | 8035 | 3748 | 4287 | 46.6 |
| 89 | | | | 8472 | 3842 | 4630 | 45.3 |
| 90 | | | | 8938 | 3938 | 5000 | 44.1 |
| 91 | | | | 9437 | 4036 | 5400 | 42.8 |
| 92 | | | | 9969 | 4137 | 5833 | 41.5 |
| 93 | | | | 10540 | 4240 | 6299 | 40.2 |
| 94 | | | | 11149 | 4346 | 6803 | 39.0 |
| 95 | | | | 11802 | 4455 | 7347 | 37.7 |
| 96 | | | | 12502 | 4566 | 7935 | 36.5 |
| 97 | | | | 13250 | 4681 | 8570 | 35.3 |
| 98 | | | | 14053 | 4798 | 9255 | 34.1 |
| 99 | | | | 14913 | 4918 | 9996 | 33.0 |
| 100 | | | | 15836 | 5041 | 10796 | 31.8 |

NOTE: The "All Other" sector is a simple trend model that projects assumed rates of growth for the R&D and non-R&D sectors through the year 2000.

Table A-5. Academic Projection Models, Nonclinical Psychology

|  |  | Employment |  |  | Nonclinical Psych Projected |  |  |  |
|---|---|---|---|---|---|---|---|---|
| Year | Total | Non-R&D | R&D | Total Beh Sc Fac. | Total Fac. | R&D | Non-R&D | % R&D |
| Assumption |  |  |  | -2.0% |  |  |  |  |
| 73 | 9452 | 7380 | 2072 | 19900 | 9452 | 7380 | 2072 | 21.9% |
| 75 | 10863 | 9016 | 1847 | 23600 | 10863 | 9016 | 1847 | 17.0% |
| 77 | 10905 | 8799 | 2106 | 25600 | 10905 | 8799 | 2106 | 19.3% |
| 79 | 11538 | 8729 | 2809 | 26900 | 11538 | 8729 | 2809 | 24.3% |
| 81 | 12586 | 9836 | 2750 | 28200 | 12586 | 9836 | 2750 | 21.9% |
| 83 | 12404 | 9785 | 2619 | 29800 | 12404 | 9785 | 2619 | 21.1% |
| 85 | 13221 | 10655 | 2566 | 31700 | 13221 | 10655 | 2566 | 19.4% |
| 87 | 13058 | 9972 | 3086 | 31800 | 13058 | 9972 | 3086 | 23.6% |
| 88 |  |  |  | 31732 | 13026 | 2745 | 10281 | 21.1% |
| 89 |  |  |  | 31635 | 12986 | 2740 | 10246 | 21.1% |
| 90 |  |  |  | 31444 | 12908 | 2724 | 10184 | 21.1% |
| 91 |  |  |  | 31166 | 12794 | 2699 | 10094 | 21.1% |
| 92 |  |  |  | 30806 | 12646 | 2668 | 9978 | 21.1% |
| 93 |  |  |  | 30369 | 12466 | 2630 | 9836 | 21.1% |
| 94 |  |  |  | 29860 | 12257 | 2586 | 9671 | 21.1% |
| 95 |  |  |  | 29283 | 12021 | 2536 | 9484 | 21.1% |
| 96 |  |  |  | 28644 | 11758 | 2481 | 9277 | 21.1% |
| 97 |  |  |  | 27945 | 11472 | 2420 | 9051 | 21.1% |
| 98 |  |  |  | 27192 | 11162 | 2355 | 8807 | 21.1% |
| 99 |  |  |  | 26388 | 10832 | 2286 | 8547 | 21.1% |
| 100 |  |  |  | 25536 | 10483 | 2212 | 8271 | 21.1% |

NOTE: The Academic Projection Model uses a quadratic regression of total behavioral faculty = f (behavioral graduate students):

1. Growth assumptions for behavioral student enrollment provided by the committee.

2. The portion of total behavioral faculty that is clinical psychology, nonclinical psychology, and "Other Behavioral Sciences" remains fixed at 1987 levels.

3. The portion of nonclinical psychology in R&D, which has averaged 21.1 percent from 1973-1987, remains fixed.

Table A-6. Industrial Projection Models, Nonclinical Psychology

| | | Employment | | Projected | | | |
|---|---|---|---|---|---|---|---|
| Year | Total | Non-R&D | R&D | Total Ind | R&D | Non-R&D | % R&D |
| Assumption | | | | 3.0% | | | |
| 73 | 1322 | 811 | 511 | 1322 | 511 | 811 | 38.6 |
| 75 | 1619 | 984 | 635 | 1619 | 635 | 984 | 39.2 |
| 77 | 1787 | 1031 | 756 | 1787 | 756 | 1031 | 42.3 |
| 79 | 1676 | 950 | 726 | 1676 | 726 | 950 | 43.3 |
| 81 | 2731 | 1765 | 966 | 2731 | 966 | 1765 | 35.4 |
| 83 | 3586 | 2481 | 1105 | 3586 | 1105 | 2481 | 30.8 |
| 85 | 3194 | 2140 | 1054 | 3194 | 1054 | 2140 | 33.0 |
| 87 | 3400 | 2511 | 889 | 3400 | 889 | 2511 | 26.1 |
| 88 | | | | 3502 | 1264 | 2238 | 36.1 |
| 89 | | | | 3607 | 1302 | 2305 | 36.1 |
| 90 | | | | 3715 | 1341 | 2374 | 36.1 |
| 91 | | | | 3827 | 1381 | 2445 | 36.1 |
| 92 | | | | 3942 | 1423 | 2519 | 36.1 |
| 93 | | | | 4060 | 1466 | 2594 | 36.1 |
| 94 | | | | 4182 | 1510 | 2672 | 36.1 |
| 95 | | | | 4307 | 1555 | 2752 | 36.1 |
| 96 | | | | 4436 | 1601 | 2835 | 36.1 |
| 97 | | | | 4569 | 1650 | 2920 | 36.1 |
| 98 | | | | 4706 | 1699 | 3007 | 36.1 |
| 99 | | | | 4848 | 1750 | 3098 | 36.1 |
| 100 | | | | 4993 | 1802 | 3191 | 36.1 |

NOTE: The Industrial Projection Model is a simple trend model that grows 1987 Employment to the year 2000 using committee assumptions of:

1. Growth of 2 percent, 3 percent and 4 percent.

2. The average proportion of total industry nonclinical psychology employment that is engaged in R&D for the 1973-1987 period (.06%) will remain fixed throughout the projection period.

Table A-7. Government Projection Models, Nonclinical Psychology

| | | Employment | | Projected | | | |
|---|---|---|---|---|---|---|---|
| Year | Total | Non-R&D | R&D | Total Gov | R&D | Non-R&D | % R&D |
| Assumption | | | | | | | |
| 73 | 1083 | 426 | 657 | 1083 | 657 | 426 | 60.7 |
| 75 | 1170 | 345 | 825 | 1170 | 825 | 345 | 70.5 |
| 77 | 1404 | 495 | 909 | 1404 | 909 | 495 | 64.7 |
| 79 | 1164 | 334 | 830 | 1164 | 830 | 334 | 71.3 |
| 81 | 1235 | 487 | 748 | 1235 | 748 | 487 | 60.5 |
| 83 | 1320 | 670 | 650 | 1320 | 650 | 670 | 49.3 |
| 85 | 1189 | 511 | 678 | 1189 | 678 | 511 | 57.0 |
| 87 | 1724 | 711 | 1013 | 1724 | 1013 | 711 | 58.7 |
| 88 | | | | 1741 | 1072 | 669 | 61.6 |
| 89 | | | | 1759 | 1083 | 675 | 61.6 |
| 90 | | | | 1776 | 1094 | 682 | 61.6 |
| 91 | | | | 1794 | 1105 | 689 | 61.6 |
| 92 | | | | 1812 | 1116 | 696 | 61.6 |
| 93 | | | | 1830 | 1127 | 703 | 61.6 |
| 94 | | | | 1848 | 1139 | 710 | 61.6 |
| 95 | | | | 1867 | 1150 | 717 | 61.6 |
| 96 | | | | 1884 | 1160 | 723 | 61.6 |
| 97 | | | | 1901 | 1171 | 730 | 61.6 |
| 98 | | | | 1918 | 1181 | 736 | 61.6 |
| 99 | | | | 1935 | 1192 | 743 | 61.6 |
| 100 | | | | 1952 | 1203 | 750 | 61.6 |

NOTE: The Government Projection Model is a simple trend model that uses the BLS estimates of growth in total psychologists (1 percent from 1987-1995; .09 percent from 1995-2000). The average proportion of scientists involved in R&D for the 1973-87 period (61.6 percent) was assumed constant over the projection period.

Table A-8. All Other Employment, Nonclinical Psychology

| | | Employment | | Projected | | | |
|---|---|---|---|---|---|---|---|
| Year | Total | Non-R&D | R&D | Total Other | R&D | Non-R&D | % R&D |
| Assumption | | | | 3.4% | -0.5% | 7.2% | |
| 73 | 1043 | 407 | 636 | 1043 | 636 | 407 | 61.0 |
| 75 | 1159 | 520 | 639 | 1159 | 639 | 520 | 55.2 |
| 77 | 1221 | 684 | 537 | 1221 | 537 | 684 | 44.0 |
| 79 | 1409 | 833 | 576 | 1409 | 576 | 833 | 40.9 |
| 81 | 1433 | 875 | 558 | 1433 | 558 | 875 | 38.9 |
| 83 | 1413 | 1022 | 391 | 1413 | 391 | 1022 | 27.7 |
| 85 | 1497 | 1111 | 386 | 1497 | 386 | 1111 | 25.8 |
| 87 | 1662 | 1075 | 587 | 1662 | 587 | 1075 | 35.3 |
| 88 | 0.0338 | 0.0718 | -0.005 | 1736 | 584 | 1152 | 33.6 |
| 89 | | | | 1795 | 581 | 1235 | 32.4 |
| 90 | | | | 1856 | 578 | 1324 | 31.2 |
| 91 | | | | 1918 | 575 | 1419 | 30.0 |
| 92 | | | | 1983 | 572 | 1521 | 28.9 |
| 93 | | | | 2050 | 569 | 1630 | 27.8 |
| 94 | | | | 2120 | 567 | 1747 | 26.7 |
| 95 | | | | 2191 | 564 | 1872 | 25.7 |
| 96 | | | | 2265 | 561 | 2007 | 24.8 |
| 97 | | | | 2342 | 558 | 2151 | 23.8 |
| 98 | | | | 2421 | 555 | 2305 | 22.9 |
| 99 | | | | 2503 | 553 | 2471 | 22.1 |
| 100 | | | | 2587 | 550 | 2648 | 21.2 |

NOTE: The "All Other" sector is a simple trend model that projects assumed rates of growth for the R&D and non-R&D sectors through the year 2000. The rates of growth are the 1973-1987 rates for non-R&D (7.2 percent per annum) and R&D (-0.5 percent per annum).

Table A-9. Academic Projection Models, Other Behavioral Sciences

| | Employment | | | | Other Behavioral Sciences Projected | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Total | Non-R&D | R&D | Total Beh Sc Fac. | Total Fac. | R&D | Non-R&D | % R&D |
| Assumption | | | | -2.0% | | | | |
| 73 | 6135 | 5201 | 934 | 19900 | 6135 | 5201 | 934 | 15.2 |
| 75 | 7621 | 6559 | 1062 | 23600 | 7621 | 6559 | 1062 | 13.9 |
| 77 | 9239 | 7784 | 1455 | 25600 | 9239 | 7784 | 1455 | 15.8 |
| 79 | 9568 | 7915 | 1653 | 26900 | 9568 | 7915 | 1653 | 17.3 |
| 81 | 9477 | 8074 | 1403 | 28200 | 9477 | 8074 | 1403 | 14.8 |
| 83 | 11002 | 9546 | 1456 | 29800 | 11002 | 9546 | 1456 | 13.2 |
| 85 | 11009 | 9530 | 1479 | 31700 | 11009 | 9530 | 1479 | 13.4 |
| 87 | 10767 | 9079 | 1688 | 31800 | 10767 | 9079 | 1688 | 15.7 |
| 88 | | | | 31732 | 10741 | 1602 | 9139 | 14.9 |
| 89 | | | | 31635 | 10708 | 1596 | 9113 | 14.9 |
| 90 | | | | 31444 | 10644 | 1586 | 9058 | 14.9 |
| 91 | | | | 31166 | 10550 | 1572 | 8978 | 14.9 |
| 92 | | | | 30806 | 10428 | 1554 | 8874 | 14.9 |
| 93 | | | | 30369 | 10280 | 1532 | 8748 | 14.9 |
| 94 | | | | 29860 | 10108 | 1506 | 8602 | 14.9 |
| 95 | | | | 29283 | 9912 | 1477 | 8435 | 14.9 |
| 96 | | | | 28644 | 9696 | 1445 | 8251 | 14.9 |
| 97 | | | | 27945 | 9459 | 1409 | 8050 | 14.9 |
| 98 | | | | 27192 | 9204 | 1371 | 7833 | 14.9 |
| 99 | | | | 26388 | 8932 | 1331 | 7601 | 14.9 |
| 100 | | | | 25536 | 8644 | 1288 | 7356 | 14.9 |

NOTE: The Academic Projection Model uses a quadratic regression of total behavioral faculty = f (behavioral graduate students).

1. Growth assumptions in behavioral student enrollment provided by the committee.
2. The portion of total behavioral faculty that is clinical psychology, nonclinical psychology, and "Other Behavioral Sciences" remains fixed at 1987 levels.
3. The portion of other behavioral sciences in R&D, which has average 14.9 percent from 1973-1987, remains fixed.

Table A-10. All Other Employment, Other Behavioral Sciences

| Year | Total | Employment Non-R&D | Employment R&D | Projected Total Ind | Projected R&D | Projected Non-R&D | Projected % R&D |
|---|---|---|---|---|---|---|---|
| Assumption | | | | 3.0% | 0.07 | 0.1491 | |
| 73 | 456 | 179 | 277 | 456 | 277 | 179 | 60.8 |
| 75 | 579 | 201 | 378 | 579 | 378 | 201 | 65.4 |
| 77 | 837 | 328 | 509 | 837 | 509 | 328 | 60.9 |
| 79 | 1277 | 450 | 827 | 1277 | 827 | 450 | 64.8 |
| 81 | 1343 | 524 | 819 | 1343 | 819 | 524 | 61.0 |
| 83 | 1476 | 1028 | 448 | 1476 | 448 | 1028 | 30.3 |
| 85 | 1680 | 1308 | 372 | 1680 | 372 | 1308 | 22.2 |
| 87 | 1969 | 1254 | 715 | 1969 | 715 | 1254 | 36.3 |
| 88 | 0.1101 | 0.1491 | 0.0700 | 2206 | 765 | 1441 | 34.7 |
| 89 | | | | 2474 | 819 | 1656 | 33.1 |
| 90 | | | | 2779 | 876 | 1903 | 31.5 |
| 91 | | | | 3124 | 937 | 2186 | 30.0 |
| 92 | | | | 3515 | 1003 | 2512 | 28.5 |
| 93 | | | | 3960 | 1073 | 2887 | 27.1 |
| 94 | | | | 4465 | 1148 | 3317 | 25.7 |
| 95 | | | | 5040 | 1229 | 3812 | 24.4 |
| 96 | | | | 5695 | 1315 | 4380 | 23.1 |
| 97 | | | | 6440 | 1407 | 5033 | 21.8 |
| 98 | | | | 7289 | 1505 | 5783 | 20.7 |
| 99 | | | | 8256 | 1611 | 6646 | 19.5 |
| 100 | | | | 9360 | 1723 | 7637 | 18.4 |

NOTE: The "All Other" projection model is a simple trend model that grows 1987 employment to the year 2000 assuming that 1973-1987 historical growth rates in the R&D (7 percent) and non-R&D (14.9 percent) would continue through 2000.

## Table A-11. Behavioral Enrollment Faculty, All Behavioral Sciences

Assumption -2.0% -2.0%

| Year | Est Behav. Undergrad Enroll | Est Behav. Grad Enroll | Estimated Total Fac | Total Student |
|---|---|---|---|---|
| 1972 | 705.8 | 44.7 | | 750.5 |
| 1973 | 695.6 | 48.2 | 19.9 | 743.8 |
| 1974 | 672.6 | 51.7 | 21.7 | 724.3 |
| 1975 | 668.1 | 55.4 | 23.6 | 723.5 |
| 1976 | 671.8 | 59.1 | 24.6 | 730.9 |
| 1977 | 663.5 | 58.3 | 25.6 | 721.8 |
| 1978 | 648.9 | 63.8 | 26.2 | 712.7 |
| 1979 | 612.8 | 63.8 | 26.9 | 676.6 |
| 1980 | 604.8 | 63.8 | 27.5 | 668.6 |
| 1981 | 593.6 | 64.8 | 28.2 | 658.4 |
| 1982 | 589.8 | 64.3 | 29.0 | 654.1 |
| 1983 | 574.5 | 63.1 | 29.8 | 637.6 |
| 1984 | 563.0 | 63.7 | 30.7 | 626.7 |
| 1985 | 551.7 | 65.6 | 31.7 | 617.3 |
| 1986 | 540.7 | 65.3 | 31.7 | 606.0 |
| 1987 | 529.9 | 65.1 | 31.8 | 595.0 |
| 1988 | 519.3 | 63.8 | 31.7 | 583.1 |
| 1989 | 508.9 | 62.5 | 31.6 | 571.4 |
| 1990 | 498.7 | 61.3 | 31.4 | 560.0 |
| 1991 | 488.8 | 60.0 | 31.2 | 548.8 |
| 1992 | 479.0 | 58.8 | 30.8 | 537.8 |
| 1993 | 469.4 | 57.7 | 30.4 | 527.1 |
| 1994 | 460.0 | 56.5 | 29.9 | 516.5 |
| 1995 | 450.8 | 55.4 | 29.3 | 506.2 |
| 1996 | 441.8 | 54.3 | 28.6 | 496.1 |
| 1997 | 433.0 | 53.2 | 27.9 | 486.2 |
| 1998 | 424.3 | 52.1 | 27.2 | 476.4 |
| 1999 | 415.8 | 51.1 | 26.4 | 466.9 |
| 2000 | 407.5 | 50.1 | 25.5 | 457.6 |

NOTE: Growth assumptions regarding enrollments in behavioral sciences were provided by the committee.

Faculty = f (behavioral graduate students)

Regression Output:

| | | |
|---|---|---|
| Constant | | 3.5676722079 |
| Std Err of Y Est | | 0.0207556027 |
| R Squared | | 0.9032859059 |
| No. of Observations | | 15 |
| Degrees of Freedom | | 12 |
| X Coefficient | 0.0001001 | -0.0000000014 |
| Standard Error of Coefficient | 0.0001713 | 0.0000000088 |

Table A-12. Summary Projections for Nonclinical Psychology

Nonclinical Sensitivity Model

| Model Assumptions (in percent) | High | Mid | Low |
|---|---|---|---|
| 1. Graduate Student Enrollment | 1.0 | 0.0 | -1.0 |
| 2. Industrial Employment Growth | 4.0 | 3.0 | 2.0 |

Projected Employment of Nonclinical Psychologists, 1973-2000
(in 100s of workers)

| | Low Case | | | Mid Case | | | High Case | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Total | R&D | % R&D | Total | R&D | % R&D | Total | R&D | % R&D |
| 1973 | 129.0 | 38.8 | 30.0 | 129.0 | 38.8 | 30.0 | 129.0 | 38.8 | 30.0 |
| 1975 | 148.1 | 39.5 | 26.6 | 148.1 | 39.5 | 26.6 | 148.1 | 39.5 | 26.6 |
| 1977 | 153.2 | 43.1 | 28.1 | 153.2 | 43.1 | 28.1 | 153.2 | 43.1 | 28.1 |
| 1979 | 157.9 | 49.4 | 31.3 | 157.9 | 49.4 | 31.3 | 157.9 | 49.4 | 31.3 |
| 1981 | 179.9 | 50.2 | 27.9 | 179.9 | 50.2 | 27.9 | 179.9 | 50.2 | 27.9 |
| 1983 | 187.2 | 47.7 | 25.5 | 187.2 | 47.7 | 25.5 | 187.2 | 47.7 | 25.5 |
| 1985 | 191.0 | 46.8 | 24.5 | 191.0 | 46.8 | 24.5 | 191.0 | 46.8 | 24.5 |
| 1987 | 198.4 | 55.7 | 28.1 | 198.4 | 55.7 | 28.1 | 198.4 | 55.7 | 28.1 |
| 1988 | 200.0 | 54.9 | 27.5 | 200.3 | 55.0 | 27.5 | 200.7 | 55.2 | 27.5 |
| 1989 | 195.5 | 54.0 | 27.6 | 202.2 | 55.5 | 27.4 | 204.9 | 56.1 | 27.4 |
| 1990 | 195.2 | 53.9 | 27.6 | 204.0 | 55.9 | 27.4 | 209.2 | 57.1 | 27.3 |
| 1991 | 194.9 | 53.9 | 27.6 | 206.0 | 56.3 | 27.4 | 213.6 | 58.1 | 27.2 |
| 1992 | 194.8 | 53.8 | 27.6 | 207.9 | 56.8 | 27.3 | 218.2 | 59.2 | 27.1 |
| 1993 | 194.7 | 53.8 | 27.6 | 210.0 | 57.2 | 27.3 | 223.0 | 60.2 | 27.0 |
| 1994 | 194.7 | 53.8 | 27.6 | 212.1 | 57.7 | 27.2 | 227.9 | 61.3 | 26.9 |
| 1995 | 194.8 | 53.7 | 27.6 | 214.2 | 58.2 | 27.2 | 232.9 | 62.5 | 26.8 |
| 1996 | 194.9 | 53.7 | 27.6 | 216.4 | 58.7 | 27.1 | 238.1 | 63.6 | 26.7 |
| 1997 | 195.1 | 53.7 | 27.5 | 218.7 | 59.2 | 27.0 | 243.4 | 64.8 | 26.6 |
| 1998 | 195.4 | 53.8 | 27.5 | 221.0 | 59.7 | 27.0 | 249.0 | 66.1 | 26.5 |
| 1999 | 195.8 | 53.8 | 27.5 | 223.4 | 60.2 | 26.9 | 254.7 | 67.4 | 26.5 |
| 2000 | 199.2 | 54.5 | 27.3 | 225.9 | 60.7 | 26.9 | 260.6 | 68.7 | 26.4 |
| Growth Rates (in percent): | | | | | | | | | |
| 1973-1987 | 3.1 | 2.6 | | 3.1 | 2.6 | | 3.1 | 2.6 | |
| 1987-1991 | -0.4 | -0.9 | | 0.9 | 0.3 | | 1.9 | 1.0 | |
| 1987-2000 | 0.0 | -0.2 | | 1.0 | 0.7 | | 2.1 | 1.6 | |

NOTE: This table does not include postdoctoral employment or unemployment.

SOURCE: Estimated by National Research Council.

Table A-12. (continued) Projections of Nonclinical Psychologists by Sector, 1987-2000
(Workers in 100s)

| | 1987 | | | 1991 | | | 2000 | | | 1987-1991 Growth | | 1987-2000 Growth | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sector | Total | R&D | % R&D | Total | R&D | % R&D | Total | R&D | % R&D | Total | R&D | Total | R&D |
| Academic | | | | | | | | | | | | | |
| Low Case | 130.6 | 30.9 | 23.6 | 121.0 | 25.5 | 21.1 | 109.8 | 23.2 | 21.1 | -1.9% | -4.6% | -1.3% | -2.2% |
| Medium Case | 130.6 | 30.9 | 23.6 | 130.6 | 27.6 | 21.1 | 130.6 | 27.6 | 21.1 | 0.0% | -2.8% | 0.0% | -0.9% |
| High Case | 130.6 | 30.9 | 23.6 | 136.7 | 28.9 | 21.1 | 158.5 | 33.5 | 21.1 | 1.2% | -1.7% | 1.5% | 0.6% |
| Industrial | | | | | | | | | | | | | |
| Low Case | 34.0 | 8.9 | 26.1 | 36.8 | 11.5 | 31.3 | 44.0 | 13.8 | 31.3 | 2.0% | 6.7% | 2.0% | 3.4% |
| Medium Case | 34.0 | 8.9 | 26.1 | 38.3 | 12.0 | 31.3 | 49.9 | 15.6 | 31.3 | 3.0% | 7.8% | 3.0% | 4.4% |
| High Case | 34.0 | 8.9 | 26.1 | 39.8 | 12.5 | 31.3 | 56.6 | 17.7 | 31.3 | 4.0% | 8.8% | 4.0% | 5.5% |
| Government | 17.2 | 10.1 | 58.7 | 17.9 | 11.1 | 61.6 | 19.5 | 12.0 | 61.6 | 1.0% | 2.2% | 1.0% | 1.3% |
| All Other Clin. Psych. | 16.6 | 5.9 | 35.3 | 19.2 | 5.8 | 30.0 | 25.9 | 5.5 | 21.2 | 3.7% | -0.5% | 3.5% | -0.5% |
| Total | | | | | | | | | | | | | |
| Low Case | 198.4 | 55.7 | 28.1 | 194.9 | 53.9 | 27.6 | 199.2 | 54.5 | 27.3 | -0.4% | -0.9% | 0.0% | -0.2% |
| Medium Case | 198.4 | 55.7 | 28.1 | 206.0 | 56.3 | 27.4 | 225.9 | 60.7 | 26.9 | 0.9% | 0.3% | 1.0% | 0.7% |
| High Case | 198.4 | 55.7 | 28.1 | 213.6 | 58.1 | 27.2 | 260.6 | 68.7 | 26.4 | 1.9% | 1.0% | 2.1% | 1.6% |

NOTE: Excludes postdoctorals and unemployed.

SOURCE: Projections by National Research Council.

Table A-13. Estimated Quit Rates for All Behavioral Scientists, 1983-1987

| Career Age | (1) Behav | (2) Behav R&D & Mgt R&D | (3) Postdoc Behav | (4) Retired | (5) Total Ph.D.s | (6) Total Ph.D.s -Retire | (7) Beh Sci per 1000 Sci | (8) Annual Quit Rate | (9) Annual R&D Quit Rate |
|---|---|---|---|---|---|---|---|---|---|
| <=5 | 41948 | 5607 | 1834 | 139 | 201127 | 200988 | 218 | | |
| 6-10 | 43488 | 6282 | 343 | 373 | 217900 | 217527 | 201 | -3.1% | -7.5% |
| 11-15 | 36561 | 4612 | 127 | 990 | 215219 | 214229 | 171 | -6.3% | -12.0% |
| 16-20 | 23923 | 2915 | 68 | 2279 | 156711 | 154432 | 155 | -3.8% | -5.3% |
| 21-25 | 13410 | 1463 | 51 | 4041 | 91497 | 87456 | 154 | -0.4% | -4.3% |
| 26-30 | 10323 | 1271 | 38 | 6428 | 67207 | 60779 | 170 | 4.2% | 9.1% |
| 31-35 | 6155 | 950 | 8 | 13162 | 55931 | 42769 | 144 | -6.5% | 1.6% |
| 36-40 | 1456 | 261 | 0 | 11772 | 26355 | 14583 | 100 | -13.7% | -8.6% |
| 41+ | 303 | 43 | 0 | 6507 | 11240 | 4733 | 64 | -16.3% | -23.8% |

SOURCE: 1983, 1985, and 1987 Survey of Doctorate Recipients, National Research Council.

Table A-14. Historical and Projected Vacancy Ratios, Nonclinical Psychology, 1973-2000

| | Annual Averages | | | | | |
|---|---|---|---|---|---|---|
| | Total | | | R&D | | |
| Year | Vacancies | Ph.D.s | Ratio | Vacancies | Post-docs | Ratio |
| 1973-78 | 1189 | 1592 | 0.75 | 385 | 196 | 1.96 |
| 1978-83 | 1386 | 1555 | 0.89 | 359 | 226 | 1.59 |
| 1983-87 | 1291 | 1435 | 0.90 | 422 | 261 | 1.61 |
| 1990-95 | | | | | | |
| Low | 995 | 1260 | 0.79 | 320 | 300 | 1.07 |
| Mid | 1252 | 1366 | 0.92 | 380 | 300 | 1.27 |
| High | 1551 | 1479 | 1.05 | 449 | 300 | 1.50 |

NOTE: Assumes that Ph.D. production changes in proportion to enrollment assumptions and postdoctoral production remains constant.

SOURCE: National Research Council.

Table A-15. Summary Projections for Other Behavioral Scientists

| Model Assumptions | | High | Mid | Low |
|---|---|---|---|---|
| 1. Graduate Student Enrollment | | 1.0% | 0.0% | -1.0% |
| 2. "All other" Employment Growth | | | | |
| | R&D | 7.0% | 5.0% | 3.0% |
| | NonR&D | 0.15 | 0.1 | 0.07 |

Projected Employment of Other Behavioral Scientists, 1973-2000
(in 100s of workers) (Grad enrollment model)

| | Low Case | | | Mid Case | | | High Case | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Total | R&D | % R&D | Total | R&D | % R&D | Total | R&D | % R&D |
| 1973 | 65.9 | 12.1 | 18.4 | 65.9 | 12.1 | 18.4 | 65.9 | 12.1 | 18.4 |
| 1975 | 82.0 | 14.4 | 17.6 | 82.0 | 14.4 | 17.6 | 82.0 | 14.4 | 17.6 |
| 1977 | 100.8 | 19.6 | 19.5 | 100.8 | 19.6 | 19.5 | 100.8 | 19.6 | 19.5 |
| 1979 | 108.5 | 24.8 | 22.9 | 108.5 | 24.8 | 22.9 | 108.5 | 24.8 | 22.9 |
| 1981 | 108.2 | 22.2 | 20.5 | 108.2 | 22.2 | 20.5 | 108.2 | 22.2 | 20.5 |
| 1983 | 124.8 | 19.0 | 15.3 | 124.8 | 19.0 | 15.3 | 124.8 | 19.0 | 15.3 |
| 1985 | 126.9 | 18.5 | 14.6 | 126.9 | 18.5 | 14.6 | 126.9 | 18.5 | 14.6 |
| 1987 | 127.4 | 24.0 | 18.9 | 127.4 | 24.0 | 18.9 | 127.4 | 24.0 | 18.9 |
| 1988 | 126.8 | 23.2 | 18.3 | 129.0 | 23.6 | 18.3 | 131.4 | 24.0 | 18.2 |
| 1989 | 126.4 | 23.2 | 18.3 | 130.7 | 23.9 | 18.3 | 135.8 | 24.7 | 18.2 |
| 1990 | 126.1 | 23.1 | 18.4 | 132.6 | 24.3 | 18.3 | 140.6 | 25.6 | 18.2 |
| 1991 | 125.9 | 23.2 | 18.4 | 134.7 | 24.7 | 18.4 | 145.9 | 26.4 | 18.1 |
| 1992 | 125.8 | 23.2 | 18.4 | 137.0 | 25.2 | 18.4 | 151.6 | 27.4 | 18.1 |
| 1993 | 125.9 | 23.2 | 18.4 | 139.5 | 25.6 | 18.4 | 158.0 | 28.4 | 17.9 |
| 1994 | 126.0 | 23.3 | 18.5 | 142.2 | 26.1 | 18.4 | 165.0 | 29.4 | 17.8 |
| 1995 | 126.4 | 23.3 | 18.5 | 145.1 | 26.6 | 18.3 | 172.8 | 30.5 | 17.6 |
| 1996 | 126.8 | 23.4 | 18.5 | 148.3 | 27.1 | 18.3 | 181.5 | 31.7 | 17.4 |
| 1997 | 127.4 | 23.5 | 18.4 | 151.8 | 27.7 | 18.2 | 191.1 | 32.9 | 17.2 |
| 1998 | 128.2 | 23.6 | 18.4 | 155.7 | 28.3 | 18.2 | 201.9 | 34.2 | 16.9 |
| 1999 | 129.1 | 23.7 | 18.4 | 159.9 | 28.9 | 18.1 | 213.9 | 35.6 | 16.6 |
| 2000 | 130.2 | 23.8 | 18.3 | 164.4 | 29.5 | 18.0 | 227.4 | 37.1 | 16.3 |
| Growth Rates: | | | | | | | | | |
| 73-87 | 4.8% | 5.0% | | 4.8% | 5.0% | | 4.8% | 5.0% | |
| 87-91 | -0.3% | -0.9% | | 1.4% | 0.7% | | 3.4% | 2.4% | |
| 87-20 | 0.2% | -0.1% | | 2.0% | 1.6% | | 4.6% | 3.4% | |

NOTE: This table does not include postdoctoral employment or unemployment.

SOURCE: Estimated by National Research Council.

Table A-15. (continued) Projections of Other Behavioral Scientists by Sector, 1987-2000
(Workers in 100s)

| Sector | 1987 | | | 1991 | | | 2000 | | | 1987-1991 Growth | | 1987-2000 Growth | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | R&D | % R&D | Total | R&D | % R&D | Total | R&D | % R&D | Total | R&D | Total | R&D |
| Academic | | | | | | | | | | | | | |
| Low Case | 107.7 | 16.9 | 15.7 | 101.4 | 15.1 | 14.9 | 89.4 | 13.3 | 14.9 | -1.5% | -2.7% | -1.4% | -1.8% |
| Medium Case | 107.7 | 16.9 | 15.7 | 107.7 | 16.0 | 14.9 | 107.7 | 16.0 | 14.9 | 0.0% | -1.3% | 0.0% | -0.4% |
| High Case | 107.7 | 16.9 | 15.7 | 114.6 | 17.1 | 14.9 | 133.0 | 19.8 | 14.9 | 1.6% | 0.3% | 1.6% | 1.2% |
| All Other | | | | | | | | | | | | | |
| Low Case | 19.7 | 7.2 | 36.3 | 24.5 | 8.0 | 32.9 | 40.7 | 10.5 | 25.8 | 5.6% | 3.0% | 5.7% | 3.0% |
| Medium Case | 19.7 | 7.2 | 36.3 | 27.1 | 8.7 | 32.1 | 56.8 | 13.5 | 23.8 | 8.3% | 5.0% | 8.5% | 5.0% |
| High Case | 19.7 | 7.2 | 36.3 | 31.3 | 9.4 | 29.9 | 94.4 | 17.2 | 18.3 | 12.3% | 7.0% | 12.8% | 7.0% |
| Total | | | | | | | | | | | | | |
| Low Case | 127.4 | 24.0 | 18.9 | 125.9 | 23.2 | 18.4 | 130.2 | 23.8 | 18.3 | -0.3% | -0.9% | 0.2% | -0.1% |
| Medium Case | 127.4 | 24.0 | 18.9 | 134.7 | 24.7 | 18.4 | 164.4 | 29.5 | 18.0 | 1.4% | 0.7% | 2.0% | 1.6% |
| High Case | 127.4 | 24.0 | 18.9 | 145.9 | 26.4 | 18.1 | 227.4 | 37.1 | 16.3 | 3.4% | 2.4% | 4.6% | 3.4% |

NOTE: Excludes postdoctorals and unemployed.

SOURCE: Projections by National Research Council.

Table A-16. Historical and Projected Vacancy Ratios, Other Behavioral Sciences, 1973-2000

| | Annual Averages | | | | | |
|---|---|---|---|---|---|---|
| | Total | | | R&D | | |
| Year | Vacancies | PhDs | Ratio | Vacancies | Post-docs | Ratio |
| 1973-78 | 1152 | 1211 | 0.95 | 289 | 97 | 2.97 |
| 1978-83 | 930 | 1093 | 0.85 | 120 | 124 | 0.97 |
| 1983-87 | 875 | 943 | 0.93 | 185 | 120 | 1.54 |
| 1987-95 | | | | | | |
| Low | 649 | 814 | 0.80 | 142 | 120 | 1.18 |
| Mid | 927 | 882 | 1.05 | 191 | 120 | 1.59 |
| High | 1353 | 955 | 1.42 | 250 | 120 | 2.08 |

NOTE: Assumes that Ph.D. production changes in proportion to enrollment assumptions and postdoctoral production remains constant. Grad model.

SOURCE: National Research Council.